CHAPTER 3. GEOMORPHOLOGY

METHODS

Channel Morphology - River Transects

Cross sections have been identified in five of the six geomorphic reaches for monitoring of bed elevation change with time. Reach 2 (RM 67 to RM 17) is canyon-bound and is not subject to channel change so it is not monitored. Two to three cross-sections in each geomorphic reach were identified for monitoring. Each cross-section is surveyed across the active river channel pre- and post-runoff each year. At lease one cross-section in the reach will span the floodplain and the full width will be surveyed every fifth year to monitor the effect of high flows on the floodplain. These were surveyed in 1999.

Table 3.1 lists the cross-sections in each geomorphic reach as identified in the Long-Term Monitoring Plan. The cross sections were selected from those established in 1962 (lettered cross-sections), those established in 1992, and new cross-sections (where existing cross-sections were not representative of a geomorphic reach). Monitoring program cross-sections are coded by geomorphic reach (e.g., CS6-02 = second cross-section in geomorphic reach 6).

Table 3.1. San Juan River channel morphology monitoring cross-section locations by geomorphic reach.

Geomorphic Reach	X-Section No.	Former Identification	River mile
6	CS6-01	NEW	175.0
	CS6-02	RT-01	168.3
	CS6-03	RT-02	154.4
5	CS5-01	RT-03	142.7
	CS5-02	RT-04	136.6
	CS5-03*	RT-05	132.7
4	CS4-01	RT-06	124.0
	CS4-02	RT-07	122.1
	CS4-03*	Section E	118.2
3	CS3-01	RT-09	90.8
	CS3-02*	RT-10	82.3**
	CS3-03	RT-11	70.0
1	CS1-01	C-01	12.7
	CS1-02	C-02	4.1

*Valley-wide cross-sections surveyed every fifth year to monitor floodplain changes
**Valley-wide cross-section located at RM 82.2

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Water depth and channel depth is obtained by stretching a marked cable across river between anchor points for each transect and measuring the channel depth relative to a local bench mark. River depths are measured with a survey level and rod at 5 ft increments unless cross-section length exceeds approximately 300 ft. In such situations, areas of the cross-section that have a change in depth of less than 0.5 ft in 10 ft may be surveyed in 10 ft increments. Substrate type at each survey point is characterized as sand or gravel/cobble and recorded. The full-width floodplain surveys were completed with a total station outside the active channel. The points surveyed correspond to grade breaks such as a change in slope, top of a hill or edge of a channel or bank.

Cobble Bar Characterization

Four cobble bars on the San Juan River (RM 173.7, RM 168.4, RM 132.0, and RM 131.0) that were identified as having attributes suitable for spawning by the Colorado pikeminnow were selected for monitoring. Topographic surveys were completed for each of these cobble bars, utilizing total station survey equipment. Control was provided by established bench marks at each location. Surveys are typically completed as soon as practical (flow at 1,000 cfs or less) after spring runoff, usually during late July or early August. However, in 1999, unusual summer storms prevented starting the surveys until the end of October.
In addition to the standard required survey data, at each cobble bar the following data were recorded.

- Point descriptions for each point. Edge-of-water points noted and recorded.

- At each non-benchmark point the depth to embeddedness and corresponding surveyed point number is recorded.

- The physical structure of each cobble bar is assessed by measurement of randomly selected particles of surface bed material. Particles are selected by the Wolman pebble count method (Wolman, 1954) over the full extent of the bar within the survey boundary. A minimum of 200 samples is typically collected in a linear pattern over the bar with a spacing of about 8-10 ft (3 steps) within the line and between lines. Particle size is determined by sieving particles through a square hole in a steel plate, cut to represent an equivalent screen size from 1 through 10 cm at 1-cm increments, then 2-cm increments through 20 cm. Particles larger than 20 cm are recorded as greater than 20 cm. Interstitial material smaller than 1 cm is recorded as < 1 cm but is not included in analysis of size distribution.

- Depth of open interstitial space (depth to embeddedness) is measured at the same time and location as the survey points to characterize topography of the bar over the extent of the spawning bar. Measurement is made by a field technician working his/her hand among rocks until the fingers just touch embedded sand. Depth of penetration, measured from adjacent average cobble top-surface, will be recorded as depth of open interstitial space (Osmundson and Scheer, 1998).

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Turbidity Monitoring

The continuous turbidity monitoring equipment installed at Shiprock and Montezuma Creek is used monitor sediment producing events. The turbidity monitoring equipment at Shiprock consists of a D&A OBS-3 turbidity probe connected to a Campbell Scientific CR-510 data logger. The probe is calibrated to read between 0 and 4000 NTU's. Turbidity is measured every hour. The equipment installed at Montezuma Creek is an OmniData data logger with an OBS-3 probe that is calibrate to measure between 0 and 3000 NTU's. Turbidity is measured every two hours. The Shiprock installations has performed flawlessly while the Montezuma Creek installations has been plagued with problems. The Montezuma Creek installation will probably be replaced in late 2000 or early 2001 depending on its performance during the Summer of 2000.

RESULTS

Channel Morphology - River Transects

Cross-section plots referenced in Table 3.1 are contained in Appendix A for 1999. The long-term valley wide cross-sections are also shown in Appendix A. The figures show the pre- and post-runoff cross-section of each transect. The bars with the various hatch patterns show the substrate conditions at the time of survey.

The relative bed elevation for each of the Reach 3-6 transects since the initial survey in 1992 is shown in Figure 3.1. In this plot, the average bed elevation of the first survey in 1992 was normalized to one meter. The change with subsequent surveys is then reported as a relative difference. A bed elevation greater than one shows net deposition since the first survey. Conversely, a bed elevation less than one shows scour. Figure 3.2 shows the minimum relative bed elevation. It shows how the minimum elevation in each of the transects has changed since the first survey in 1992. The transects that were first surveyed in 1999 are not shown.

The variability makes Figures 3.1 and 3.2 difficult to interpret. Figures 3.3 and 3.4 are the average relative and minimum relative bed elevation, respectively. The values represented in figures 3.3 and 3.4 are calculated by averaging the individual bed elevations as shown in Figures 3.1 and 3.2 for each survey date. Figure 3.5 shows the cumulative deposition and scour for the Reach 3-6 transects for 1992 to 1999. The net change line shows that on average the channel has aggraded back near 1992 levels following a period of scour. However, the deepest part of the cross-sections remain 0.1 meter lower than in 1992. Figure 3.5 shows that most of the change during the period has been scour and deposition of sand, with relatively little net change in cobble, although there has been a slight net loss of cobble over the 7-year period. The figures also show the post-runoff filling of the cross-sections with sediment and the subsequent flushing between years. Table 3.2 shows the volume and peak discharge in each year. Typically, the largest scour occurs during the highest flow years although heavy sediment inflow can refill a previous year's scour, even in the relatively wet years.

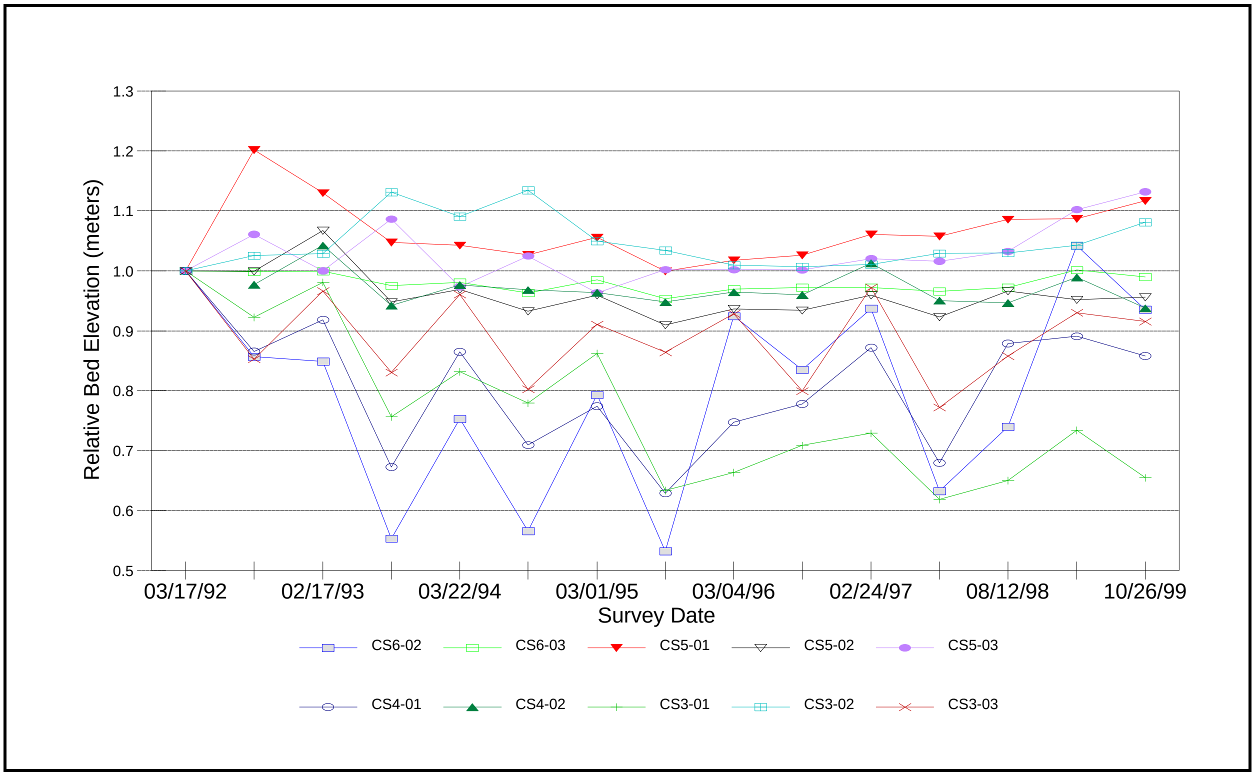

Figure 3.1. Average relative bed elevation for Reach 3-6 transects, 1992-1999.

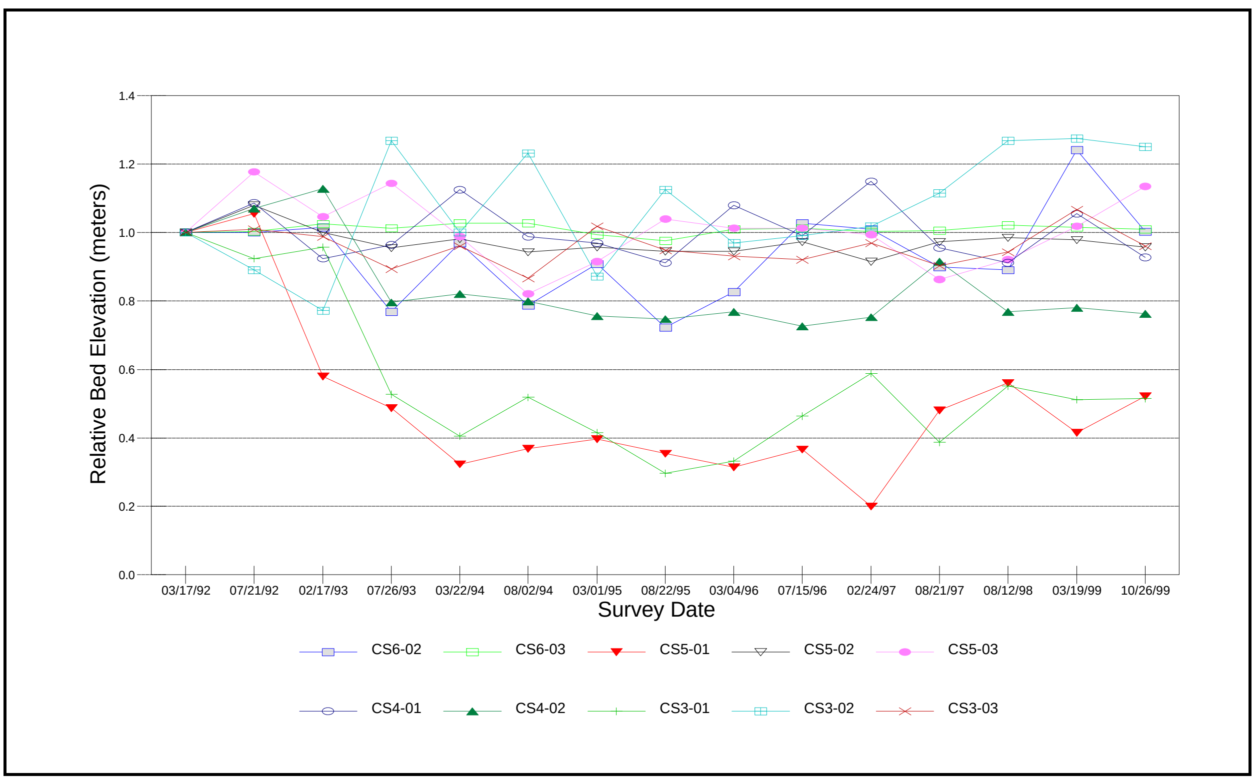

Figure 3.2. Minimum relative bed elevation for Reach 3-6 transects, 1992-1999

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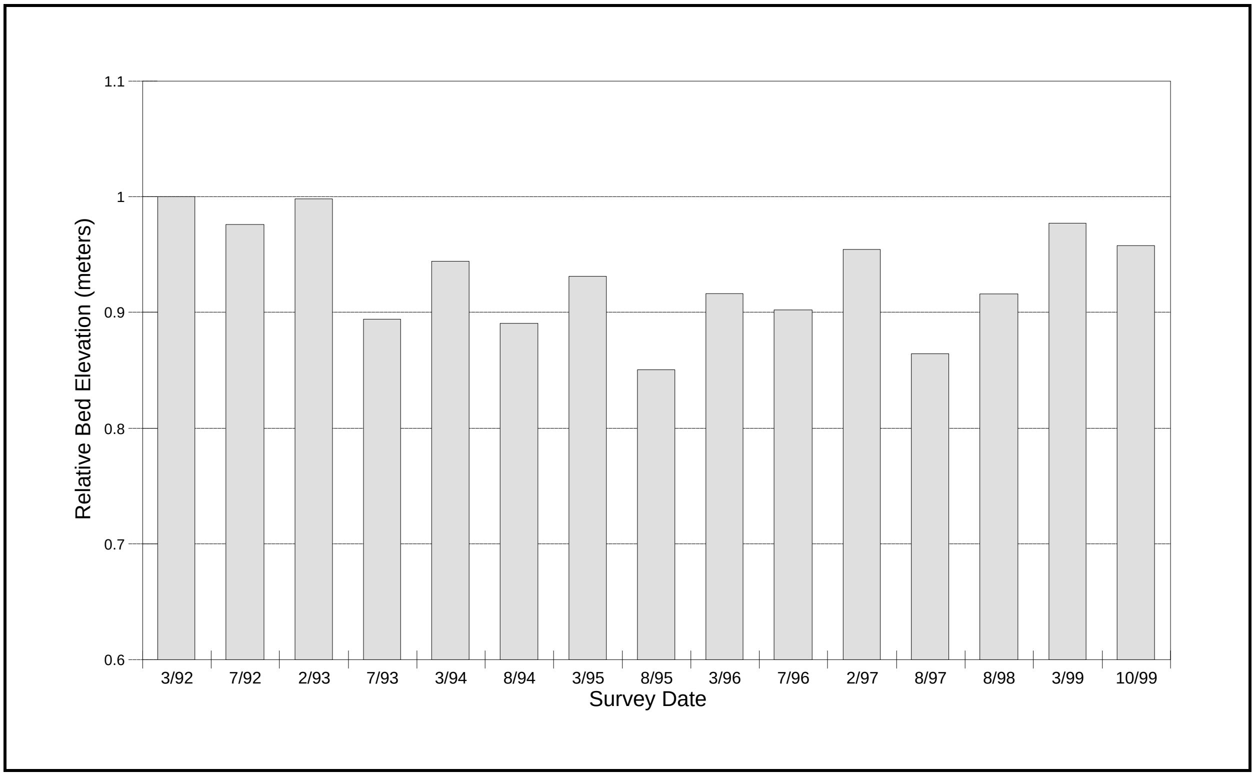

Figure 3.3. Mean relative bed elevation for Reach 3-6 Transects, 1992-1999

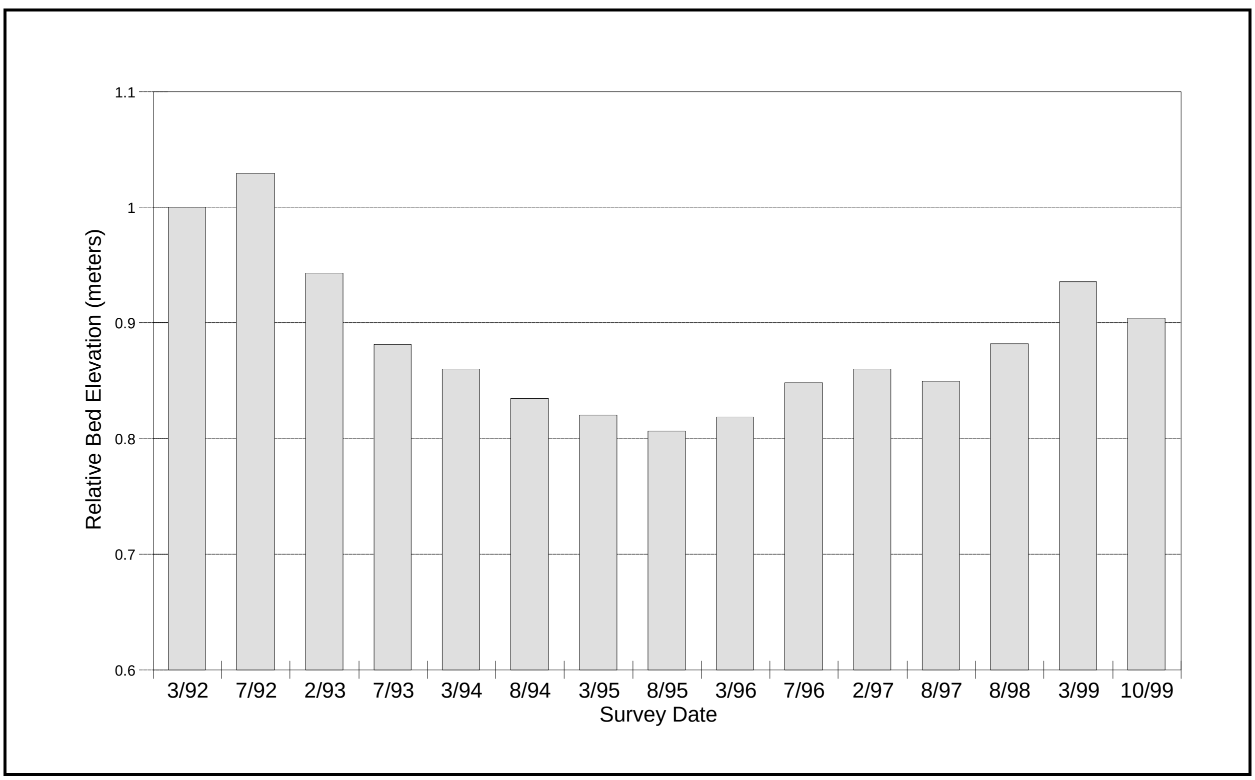

Figure 3.4. Minimum bed elevation averaged for Reach 3-6 Transects, 1992-1999

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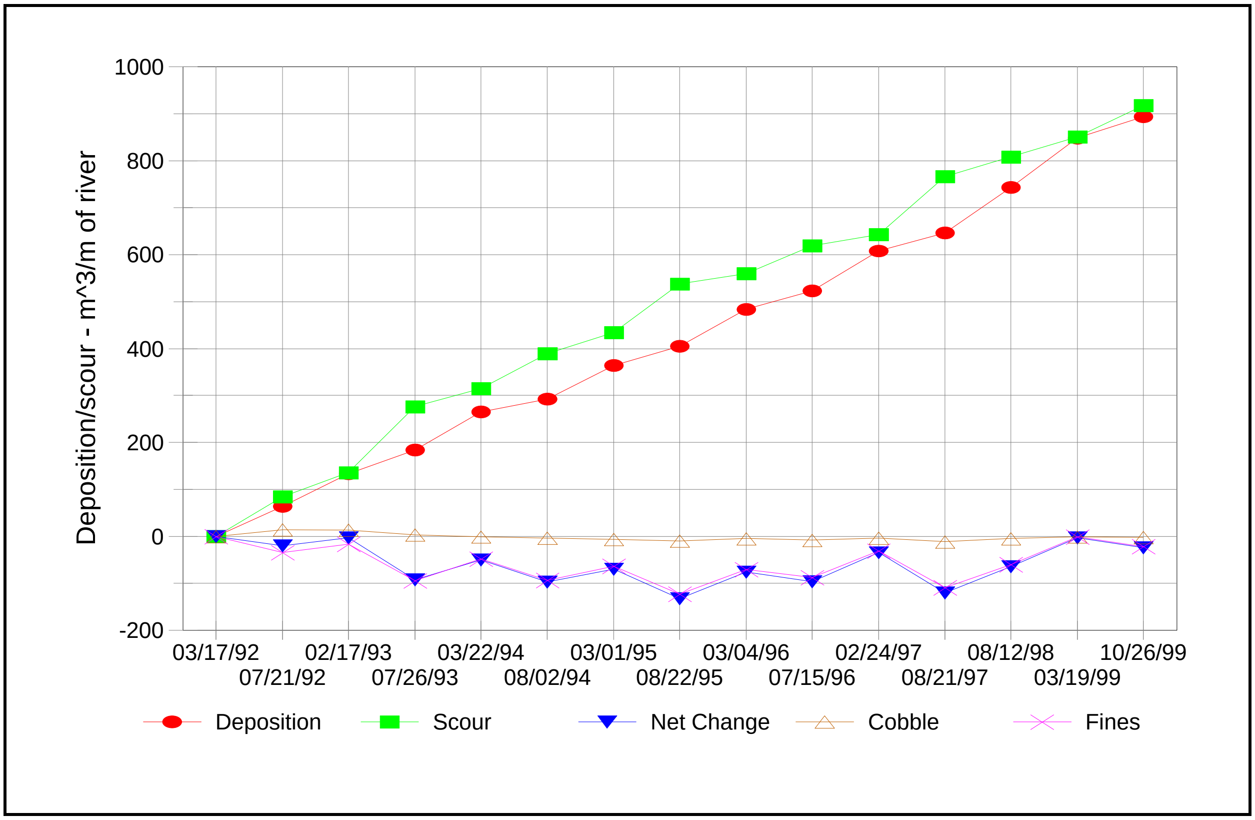

Figure 3.5. Net change in Reach 3-6 Transects, 1992-1999

Table 3.2. Peak discharge and Volume at Bluff (1991 - 1999)

Year	March to July Runoff Volume (ac-ft)	Peak Flow (cfs)
1991	574,000	4,530
1992	1,026,000	8,510
1993	1,681,000	9,650
1994	887,000	8,290
1995	1,504,000	11,600
1996	421,000	3,280
1997	1,279,000	11,300
1998	871,000	8,070
1999	812,000	7,420

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The 1999 cross-section surveys and other field data collection were completed after an unusually high flow period in August and the first half of September. The average flow at Bluff between August 1 and September 15, 1999 was nearly 5,900 cfs, with peaks exceeding 8,000 cfs. For this same period in 1992 to 1998, the average flow at Bluff was approximately 1,200 cfs. Since the 1999 runoff season peak was only 7,400 cfs, some of the system cleaning or decrease in average relative bed elevation may be due to the late high flow conditions.

Measurement of Change in Reach 1 Cross-Sections

The mean bed elevation for each Reach 1 transect is shown in Figure 3.6. The average bed elevation for both transects is shown in Figure 3.7. All data were normalized to use the October 1993 survey as the baseline and the relative elevation of each transect was set to 1.0 meter for that survey. These transects are located in a canyon reach that is influenced by Lake Powell. There is approximately 40-ft of sediment, primarily sand, deposited in the bottom of the canyon in this location. This makes the river bottom very mobile. The thalweg is constantly shifting by eroding and depositing sand shoals. Most of the change in the two cross-sections through July 1996 is a result of this erosion and deposition within the cross-sections.

Beginning in 1996, the elevation of the downstream cross-section (CS1-02) began increasing. CS1-01 began increasing in 1997. Both are at maximum in the fall of 1999. Prior to 1995, Lake Powell levels were sufficiently low to not influence this reach. Even though the lake levels were low, rerouting of the channel at RM 0 placed the channel on a sandstone ledge, preventing erosion upstream. In 1995 lake levels reached a level sufficient to submerge the waterfall that had developed at the ledge, but did not markedly impact channel elevations upstream until 1996. Between 1996 and the 1999, the bed elevation gradually increased in response to this backwater effect. A plot of Lake Powell water surface elevation is shown in Figure 3.8. Also shown is the approximate elevation of the waterfall.

Substrate is 100% sand for both of these transects and will remain so regardless of the elevation of the bed. The changes in bed elevation in this reach (below RM 18) are more influenced by Lake Powell than San Juan River discharge.

Cobble Substrate Characterization

Topographic Changes in Cobble Bars

Topographic surveys were completed for the cobble bars at RM 173.7, 168.4, 132 (M-6) and 131 (M-4). The rendered images for the latest survey as well as images for the previous surveys are shown in Figures 3.9, 3.10, 3.11, and 3.12. Each color band represents 15-cm (6-inches) of elevation change. Table 3.3 summarizes the elevation changes of three of the four bars. The cobble bar at RM 131 (M-4) is not included because the survey boundaries have been inconsistent. This will rectified on future surveys.

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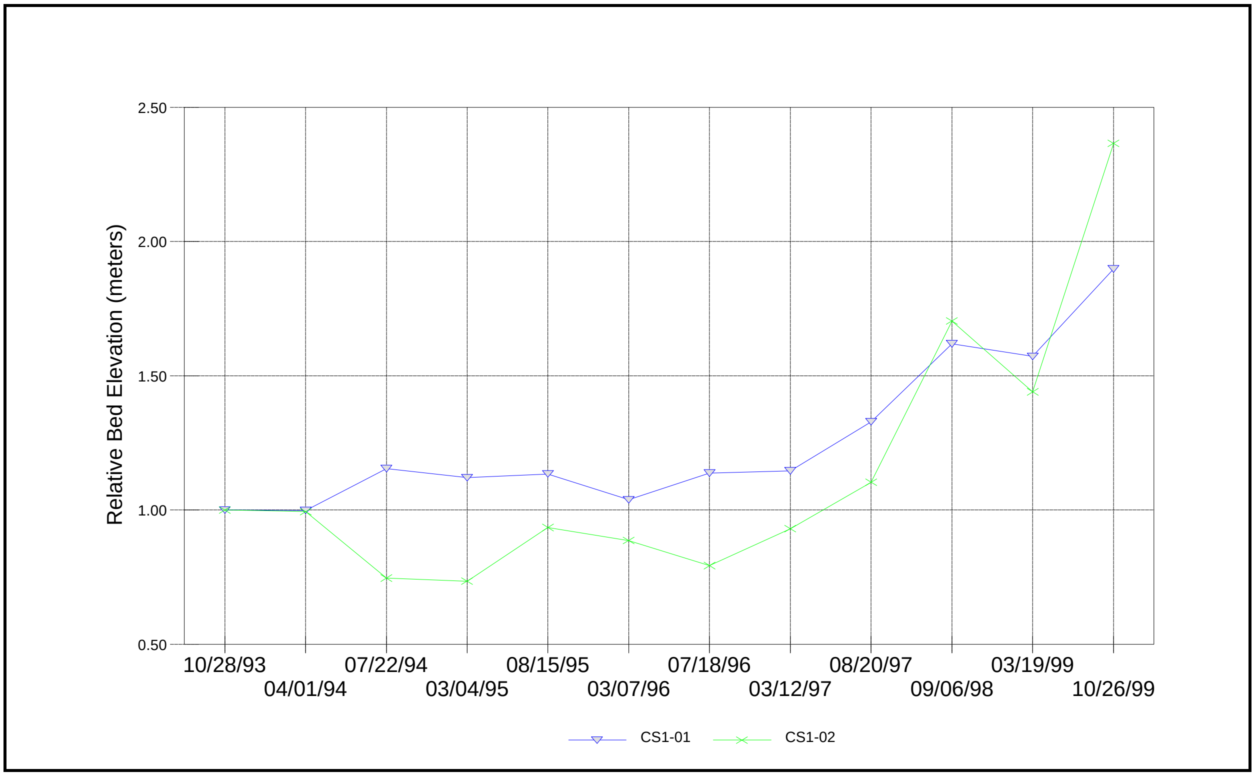

Figure 3.6 Average relative bed elevation for Reach 1 transects, 1993-1999.

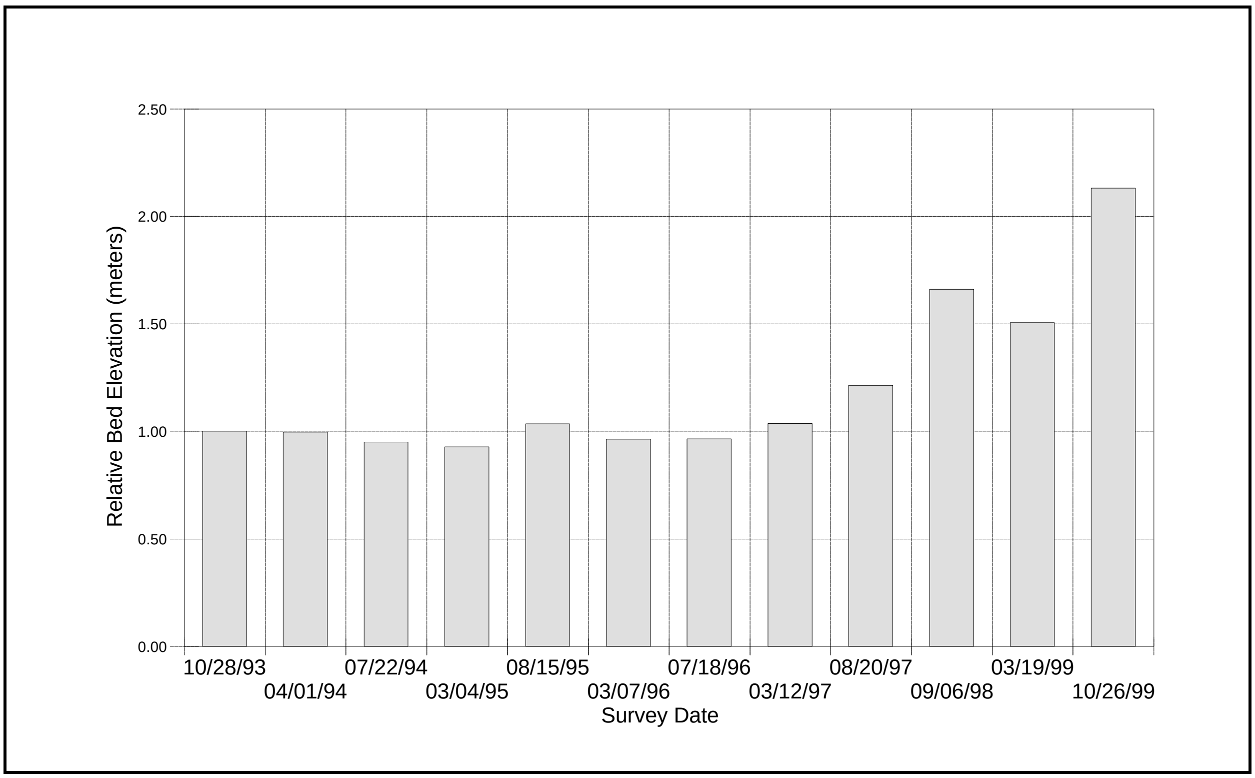

Figure 3.7. Bed elevation averaged for both transects in Reach 1, 1993-1999

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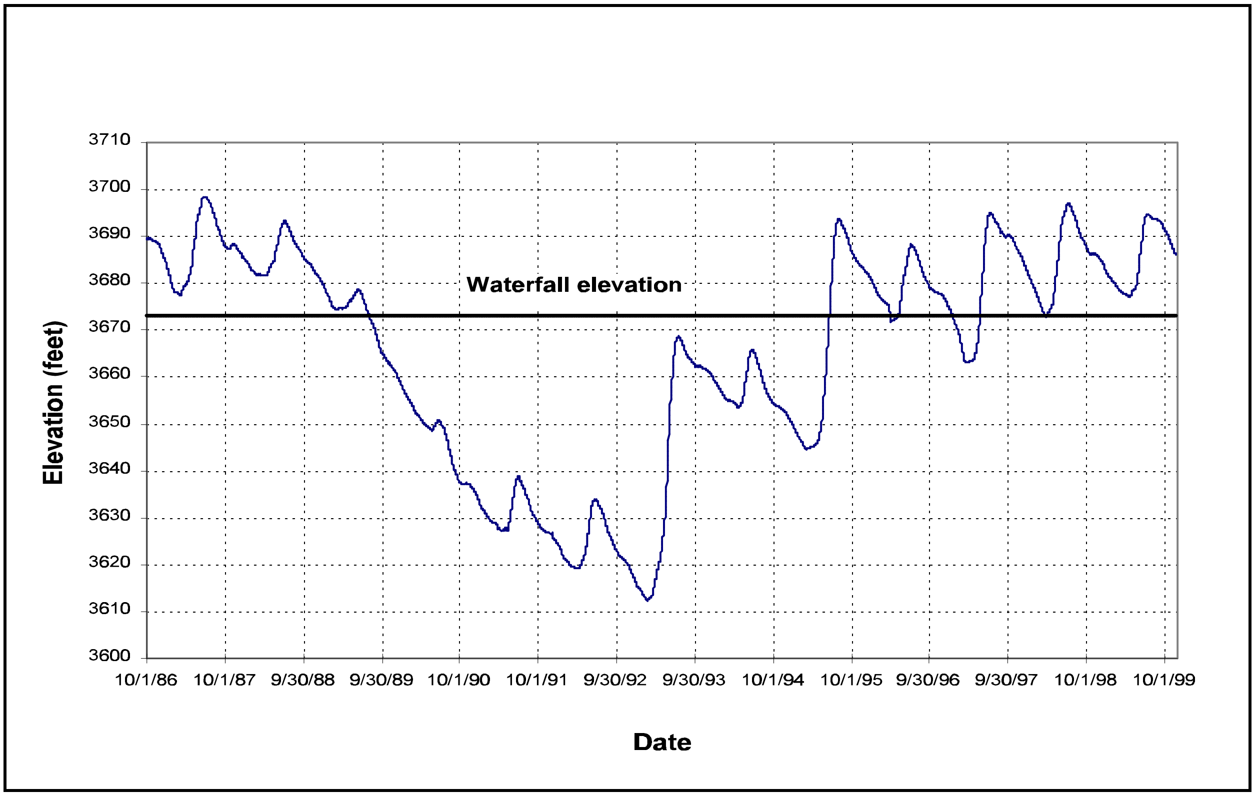

Figure 3.8. Lake Powell water surface elevation, 1986-1999.

Table 3.3. Summary of cobble bar change for bars at RM 173.7, 168.4 and 132.

Survey Date	Average Elev. (M)	Change in Elev. (m)	Max Elev. (m)	Min Elev. (m)
		Bar at RM 173.7		
04/02/96	30.48		28.90	27.13
07/08/96	30.52	3.7	28.80	27.28
08/22/97	30.41	-10.4	28.96	26.76
08/10/98	30.44	3.0	28.90	26.70
11/15/99	30.43	-1.2	28.93	26.82
		Bar at RM 168.4		
04/03/96	30.48		29.00	27.86
07/09/96	30.47	-0.9	28.99	27.46
08/22/97	30.50	2.4	28.99	27.91
07/29/98	30.54	4.3	29.11	27.84
11/16/99	30.60	6.7	29.43	28.00
		Bar at RM 132		
03/08/95	30.48		28.73	26.91
07/25/95	30.57	8.5	28.80	27.19
03/13/96	30.56	-0.9	28.68	27.04
07/10/96	30.54	-1.5	28.55	27.00
08/21/97	30.64	10.7	28.52	26.76
08/11/98	30.68	3.7	28.67	27.06
10/28/99	30.76	7.9	28.69	27.28

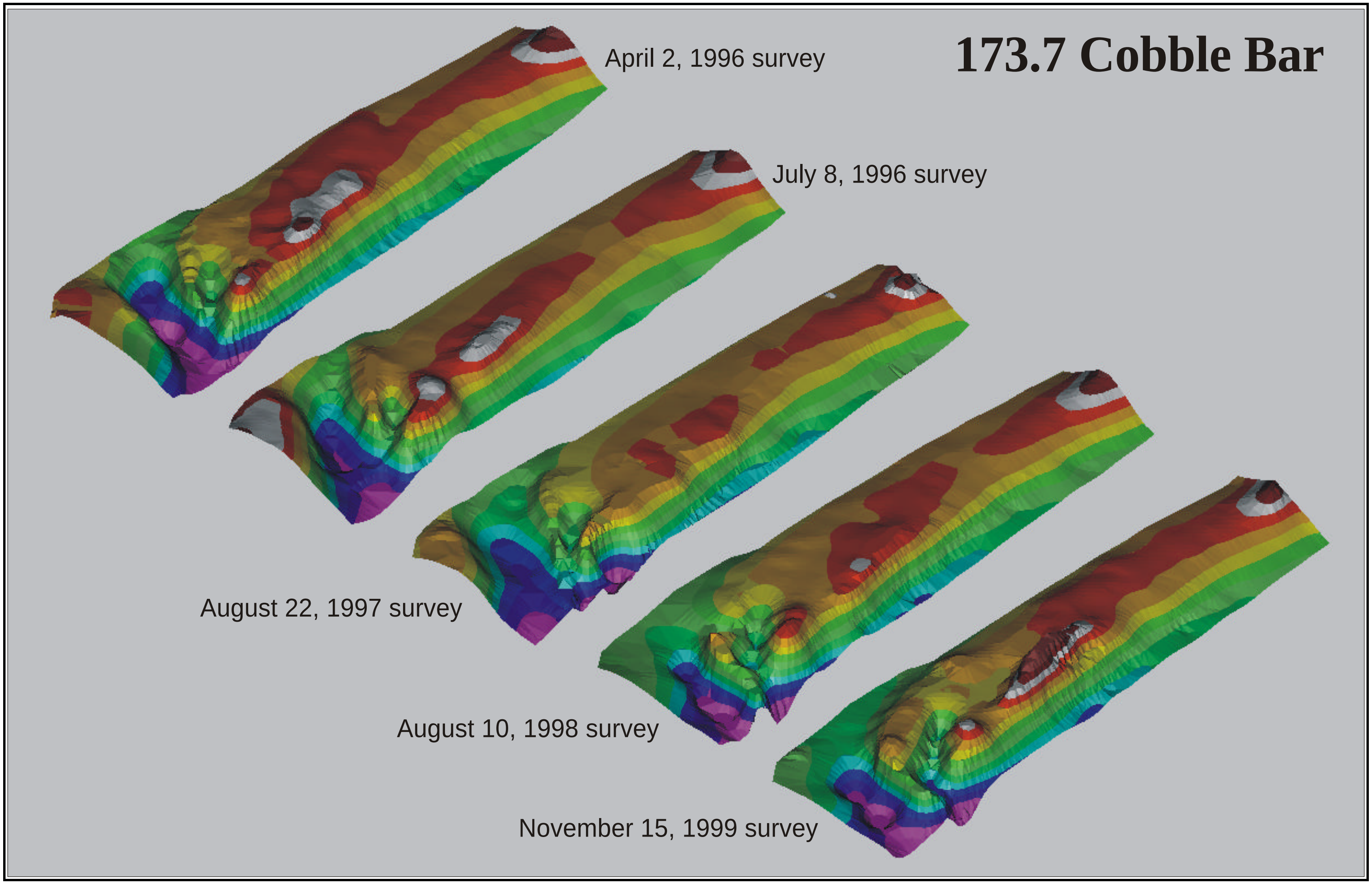

Figure 3.9. Topography of cobble bar at RM 173.7, 1993-1999

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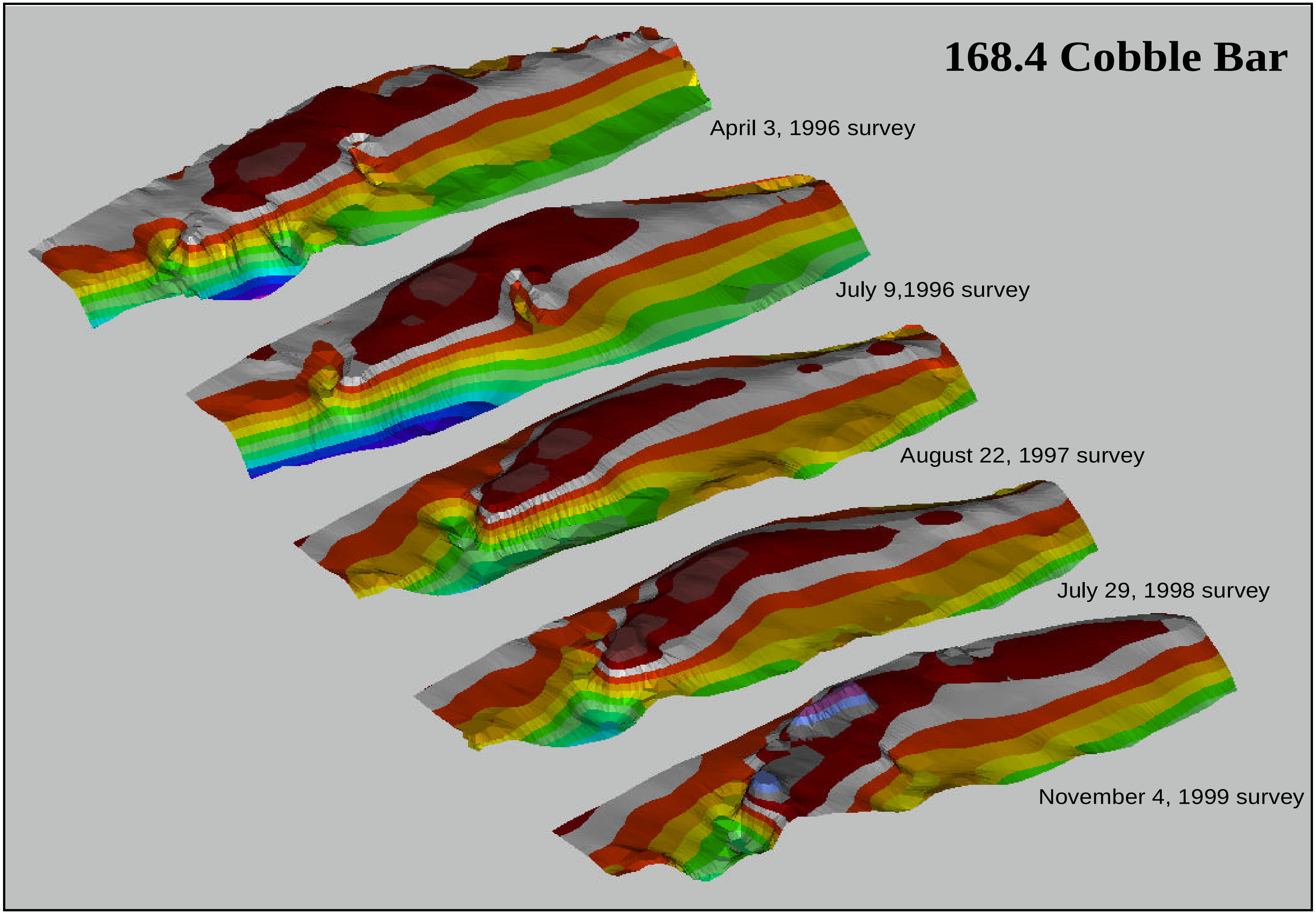

Figure 3.10. Topography of cobble bar at RM 168.4, 1993-1999.

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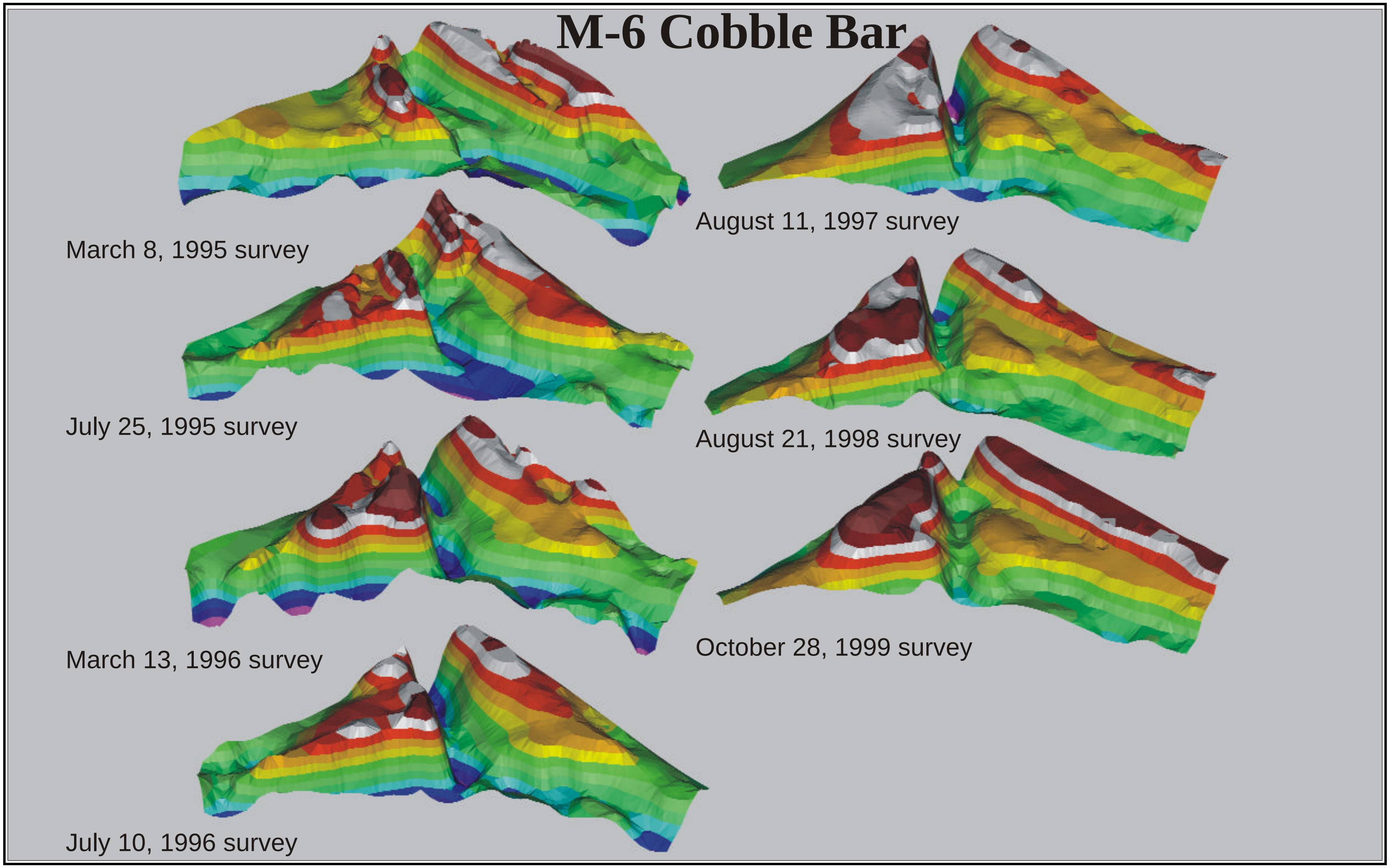

Figure 3.11. Topography of cobble bar at RM 132, 1995-1999.

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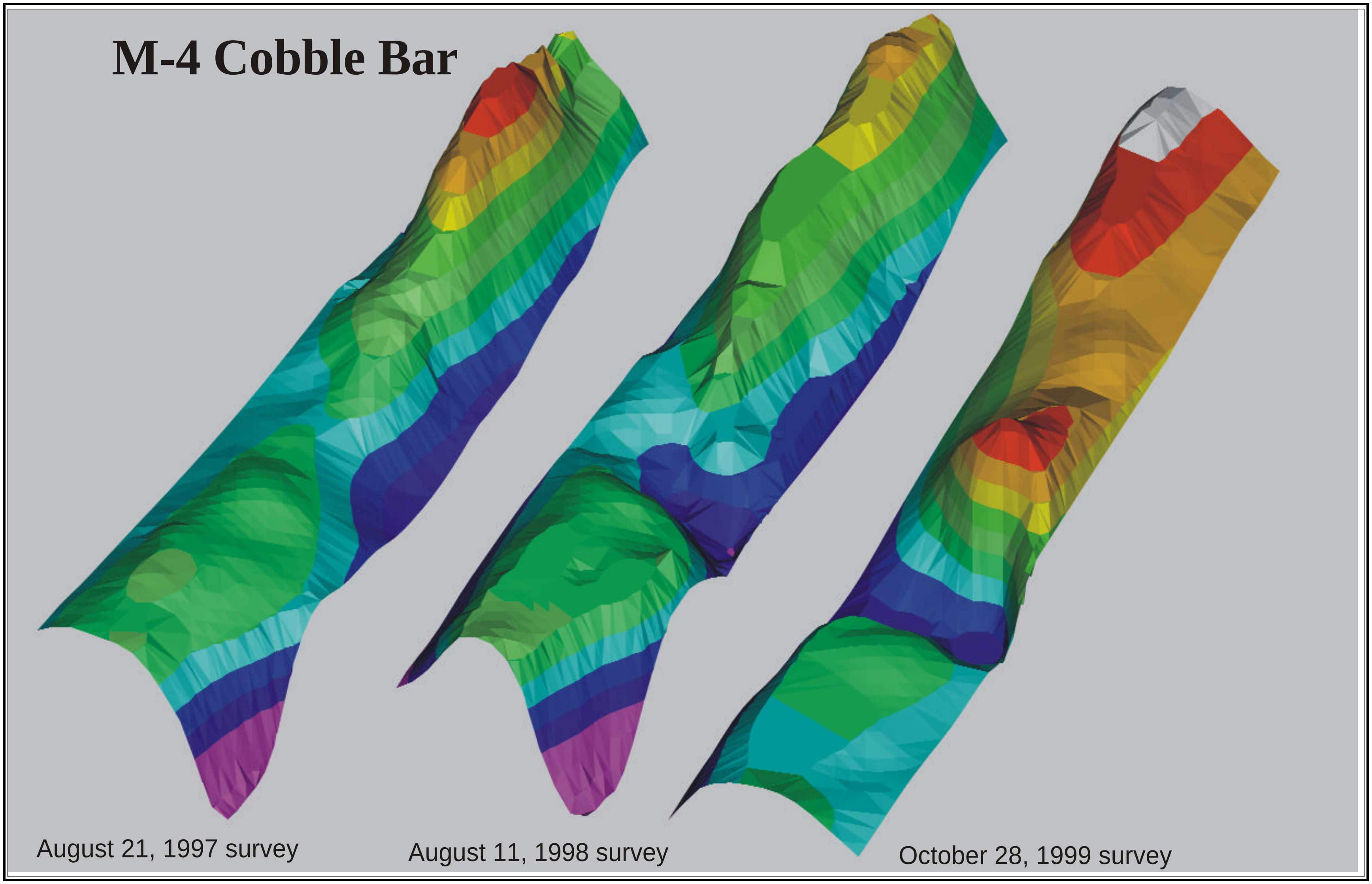

Figure 3.12. Topography of cobble bar at RM 131, 1997-1999

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The cobble bar at RM 173.7 showed slight overall scour of 1.2 cm. This is within survey error so the average elevation was essentially unchanged. Both the maximum and minimum elevation increased. Figure 3.13 shows areas of deposition and scour between the 1998 and 1999 survey. The top image in each figure shows areas of deposition and the bottom image shows areas of scour. The deposition and scour has been separated to more clearly illustrate how the bar changed between the 1998 and 1999 surveys.

The cobble bars at 168.4 and 132 were depositional in 1999 and have been since 1996. Both the minimum and maximum elevations increased from 1998 to 1999 further showing deposition. Figures 3.14 and 3.15 show areas of deposition and scour for both 132 (M-6) and 168.4.

Characterization of Bed Material

Table 3.4 shows the surface substrate composition for the 1999 pre- and post-runoff surveys of the Reach 3-6 transects. The pre-runoff survey averaged 69% sand and 31% cobble. The post-runoff survey averaged 55% sand and 45% cobble. The increase in the cobble percentage in the post-runoff survey shows that some fines were flushed from the system during runoff. Figure 3.16 shows the composition of the scour and deposition that occurred at each of the Reach 3-6 transects. Most of the material moved was fines. However, there was some cobble movement at most of the transects, particularly at CS4-02. This occurred with a 7,400 cfs peak at Bluff. Figure 3.17 simply shows the percent cobble substrate for all surveys of the Reach 3-6 transects.

The cobble size distribution for each of the four surveyed cobble bars is shown in Table 3.5. In all cases, the cobble size is somewhat larger than in 1998, but as large, on average as 1996, the year with the largest cobble. In general, the cobble size is not correlated to river mile within the sample range (RM 131 - 173.7) and there are no increasing or decreasing trends.

Depth of Open Interstitial Space

Depth of open interstitial space was also measured at each cobble bar. Figures 3.18 through 3.21 show three-dimensional plots of the four cobble bars at river mile 173.7, 168.4, 132 (M-6) and 131 (M-4) for the post-runoff 1999 survey. The “posts” seen on the surface of each image represent the depth of open interstitial space as measured at that point. Each color band on the posts indicate 1-cm of embeddedness or open interstitial space. The higher posts represent areas with greater open interstitial space.

Figures 3.22 and 3.23 show the frequency distribution of depth of open interstitial space for cobble bar 173.7. The depth is expressed in centimeters in the top plot and as multiples of the d50 cobble size in the bottom plot. Similar data are shown in Figures 3.24 to 3.29 for the cobble bars at 168.4, 132 (M-6) and 131 (M4). The actual area represented by a particular depth of exceedence is shown in Figures 3.30 to 3.33. These figures may be used to put the relative size of the cobble bars in perspective. The cobble bar at 173.7 and 168.4 are over 5,000 m^2 while the bar at 131 (m-4) is only 1,000 m^2. In these plots the area represented by a single reading is the average area which is calculated by dividing the gross area by the number of readings.

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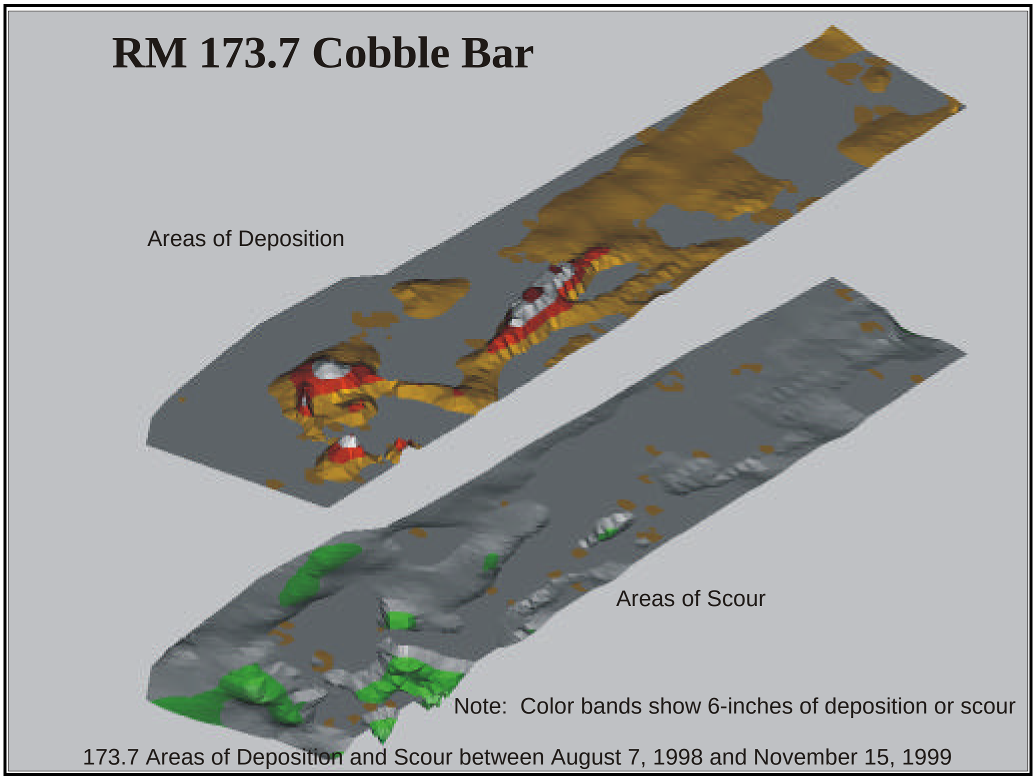

Figure 3.13. Areas of scour and deposition pre- to post-runoff for the RM 173.7 cobble bar.

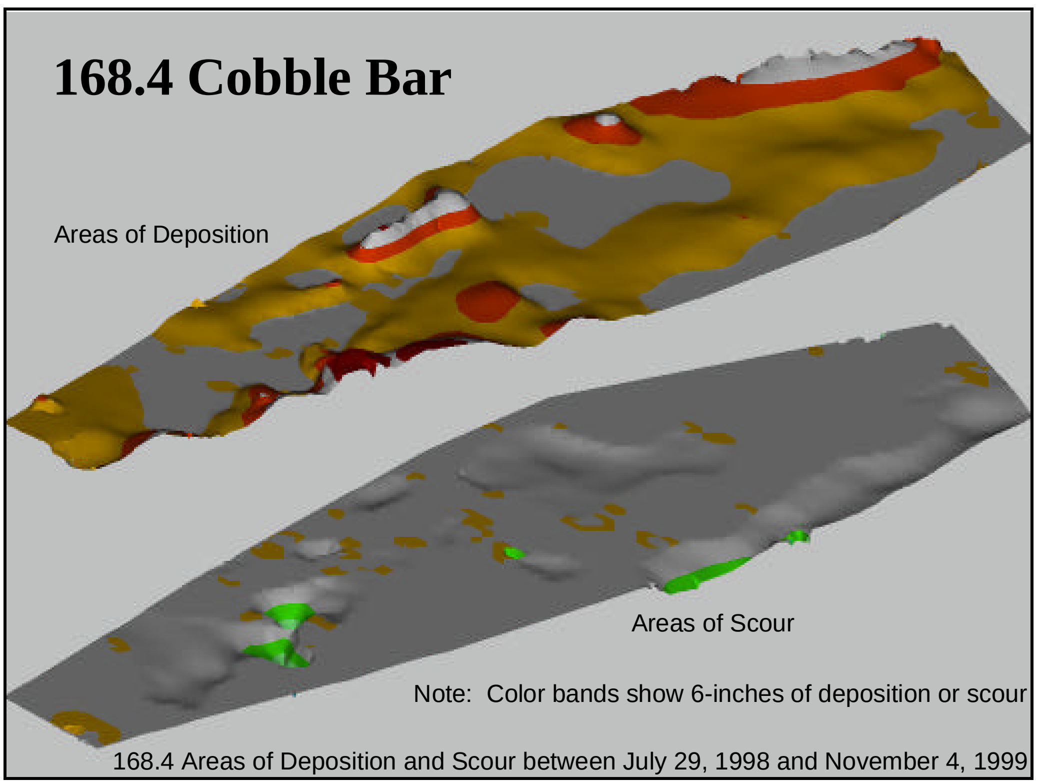

Figure 3.14. Area of scour and deposition pre- to post-runoff for the RM 168.4 cobble bar.

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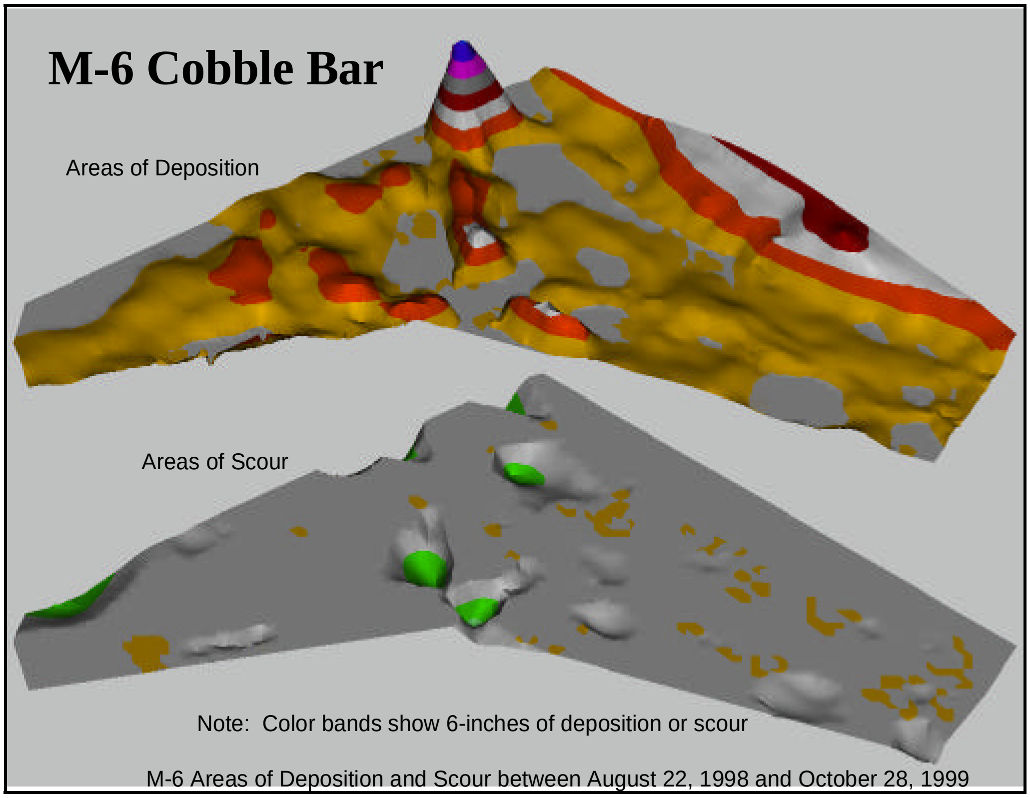

Figure 3.15. Area of scour and deposition pre- to post-runoff for the RM 132 cobble bar.

Table 3.4. Summary of percent cobble substrate, pre- and post-runoff, 1999 for Reach 3-6 transects.

Survey date	03/19/99	10/26/99
Transect	percent cobble	
CS6-02	0%	20%
CS6-03	38%	56%
CS5-01	31%	62%
CS5-02	42%	47%
CS5-03	42%	43%
CS4-01	9%	20%
CS4-02	60%	72%
CS3-01	19%	34%
CS3-02	58%	64%
CS3-03	7%	26%
Average	31%	45%

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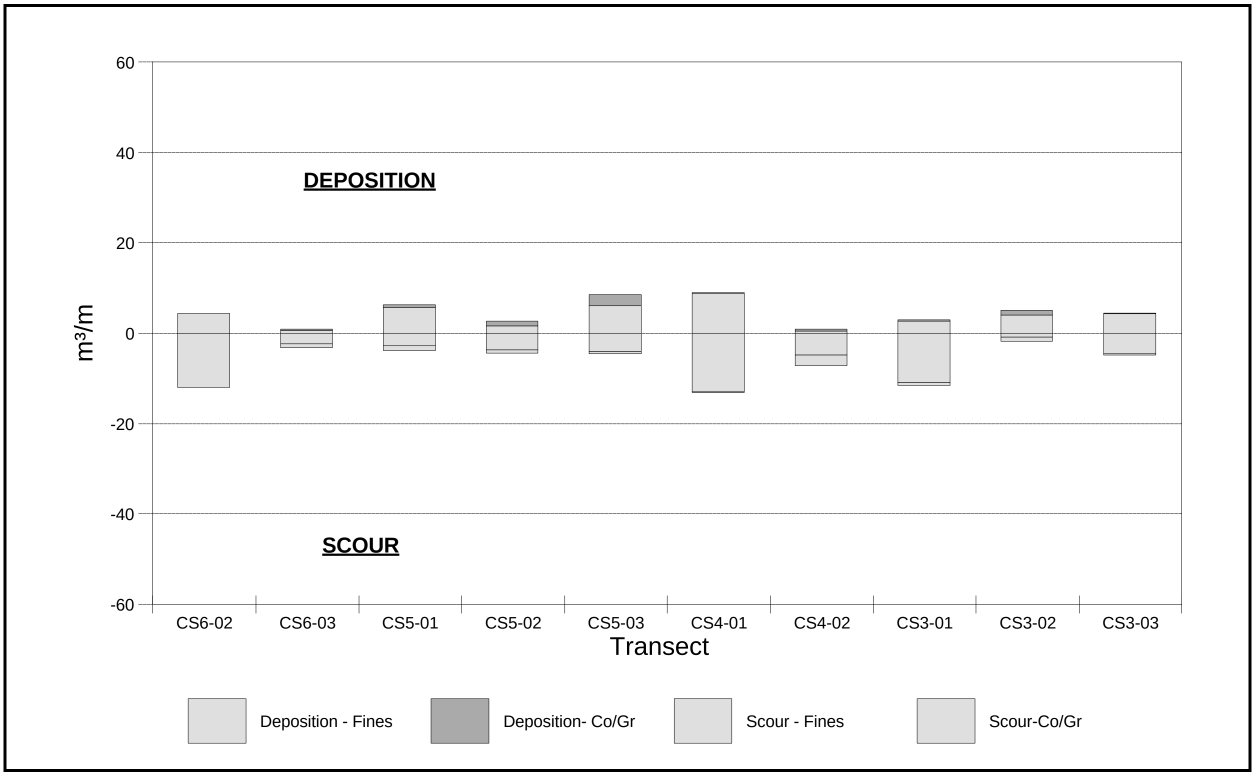

Figure 3.16. Scour and deposition composition at Reach 3-6 transects between pre- and post-runoff, 1999.

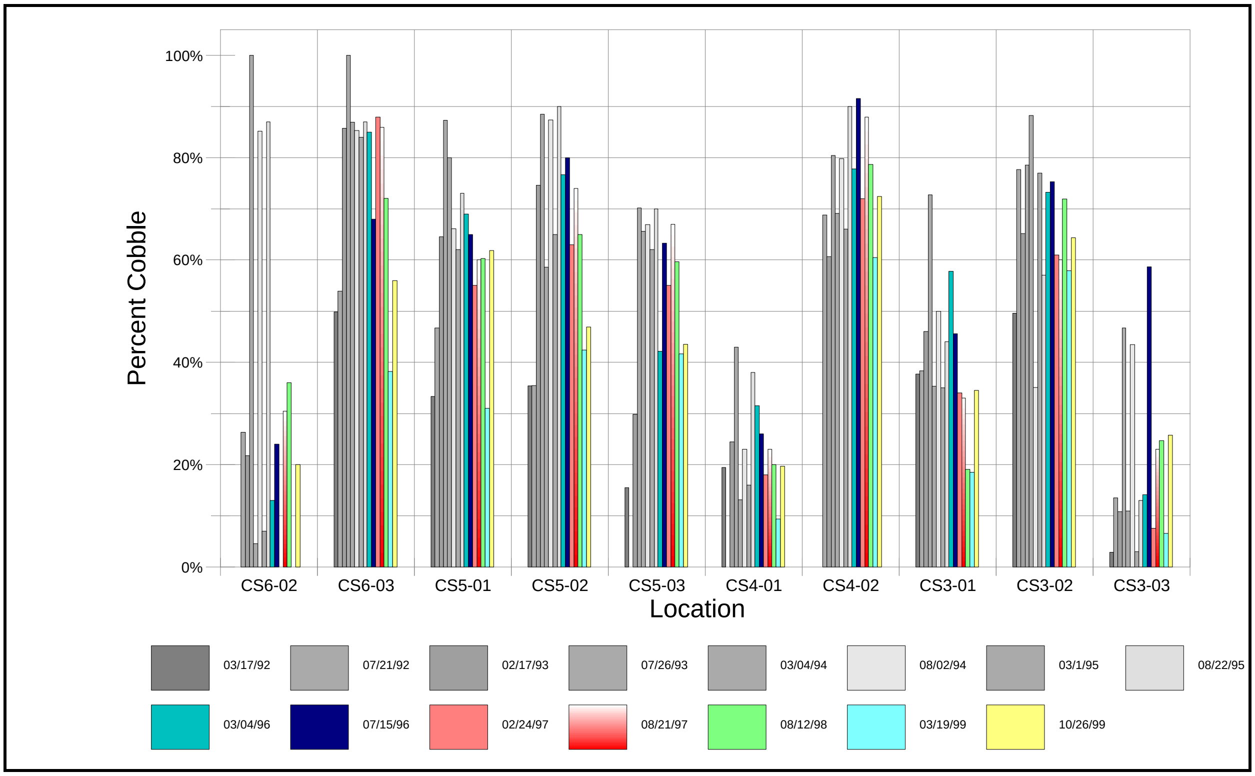

Figure 3.17. Cobble percentage at each transect, 1992-1999.

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Table 3.5. Cobble size distribution for the four surveyed cobble bars.

Year	1995	1996	1997	1998	1999
Size Fraction	Cobble Size - cm				
			RM 173.7		
D84	n/a	9.93	12.57	12.02	16.68
D75	n/a	7.95	8.00	10.33	13.17
D50	n/a	4.83	3.79	6.96	8.03
D25	n/a	3.03	2.19	4.72	4.41
D16	n/a	2.59	1.69	3.89	3.33
			RM 168.8		
D84	10.97	14.65	10.45	11.24	11.91
D75	10.17	12.62	10.00	9.94	11.00
D50	7.21	8.38	6.25	6.79	7.45
D25	4.94	4.99	4.33	4.65	5.41
D16	4.57	4.58	3.65	3.64	4.64
			RM 132 (M6)		
D84	8.64	11.64	9.90	9.49	9.98
D75	7.28	10.64	8.38	8.18	8.52
D50	5.10	7.79	6.58	5.91	6.04
D25	3.35	5.54	4.88	3.70	4.08
D16	2.75	4.60	4.40	3.03	3.44
			RM 131 (M4)		
D84	6.48	10.82	7.88	8.49	9.98
D75	5.43	9.81	7.06	6.95	8.50
D50	4.17	7.96	5.20	4.64	6.64
D25	2.80	6.58	3.56	2.54	4.68
D16	2.09	5.60	2.76	1.92	4.15

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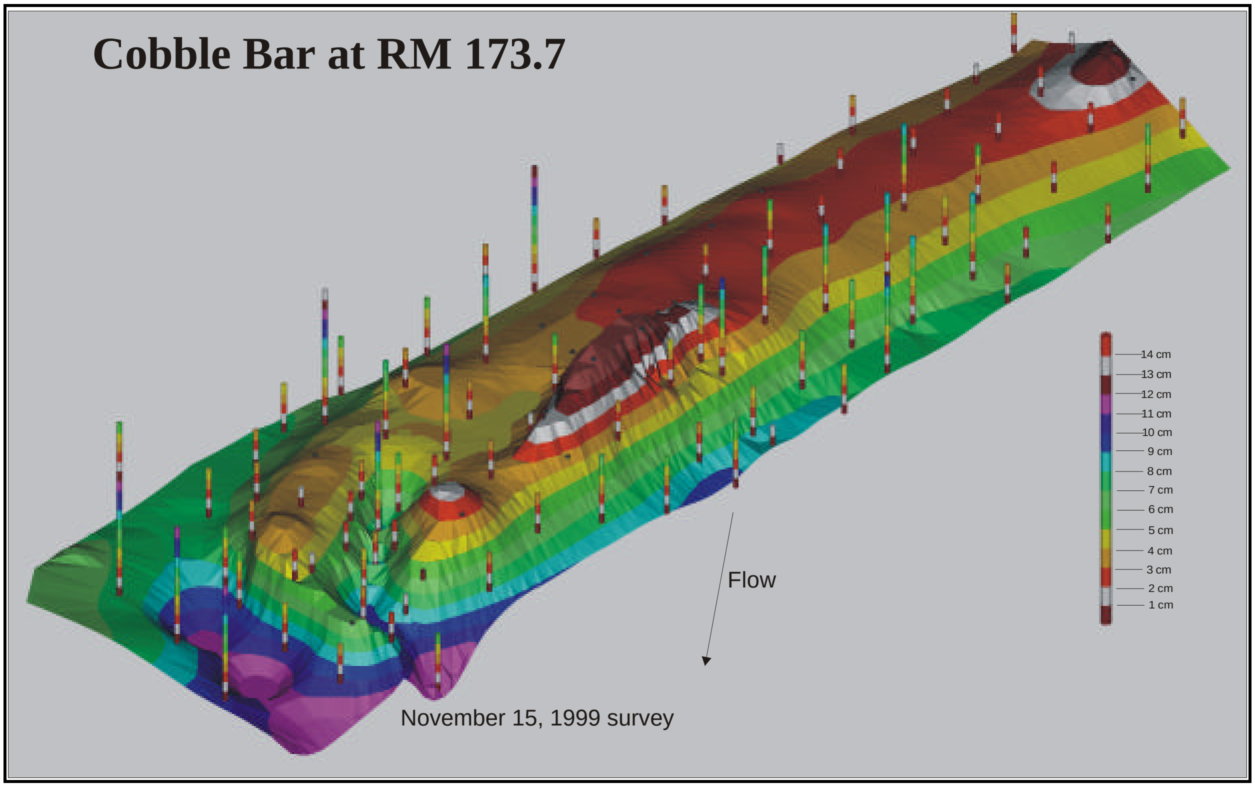

Figure 3.18. November 15, 1999 survey with embeddedness markers.

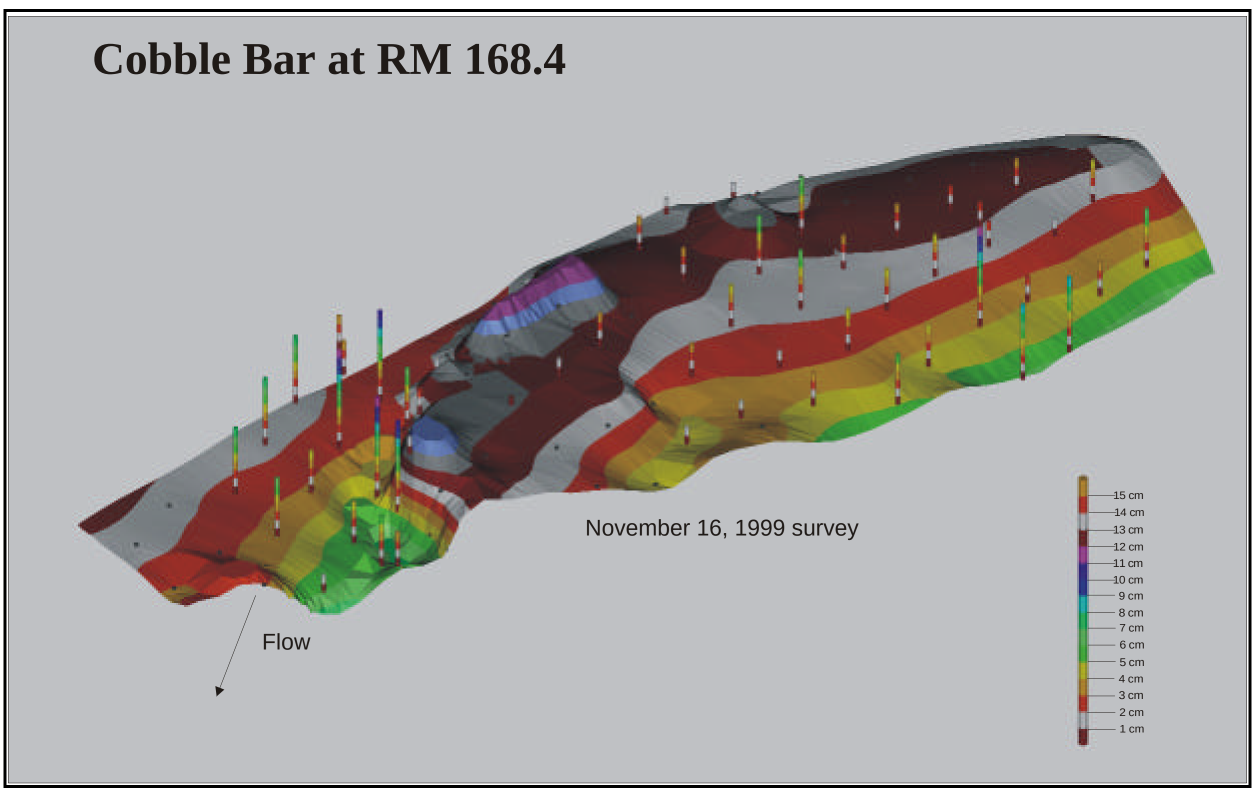

Figure 3.19. November 16, 1999 survey with embeddedness markers.

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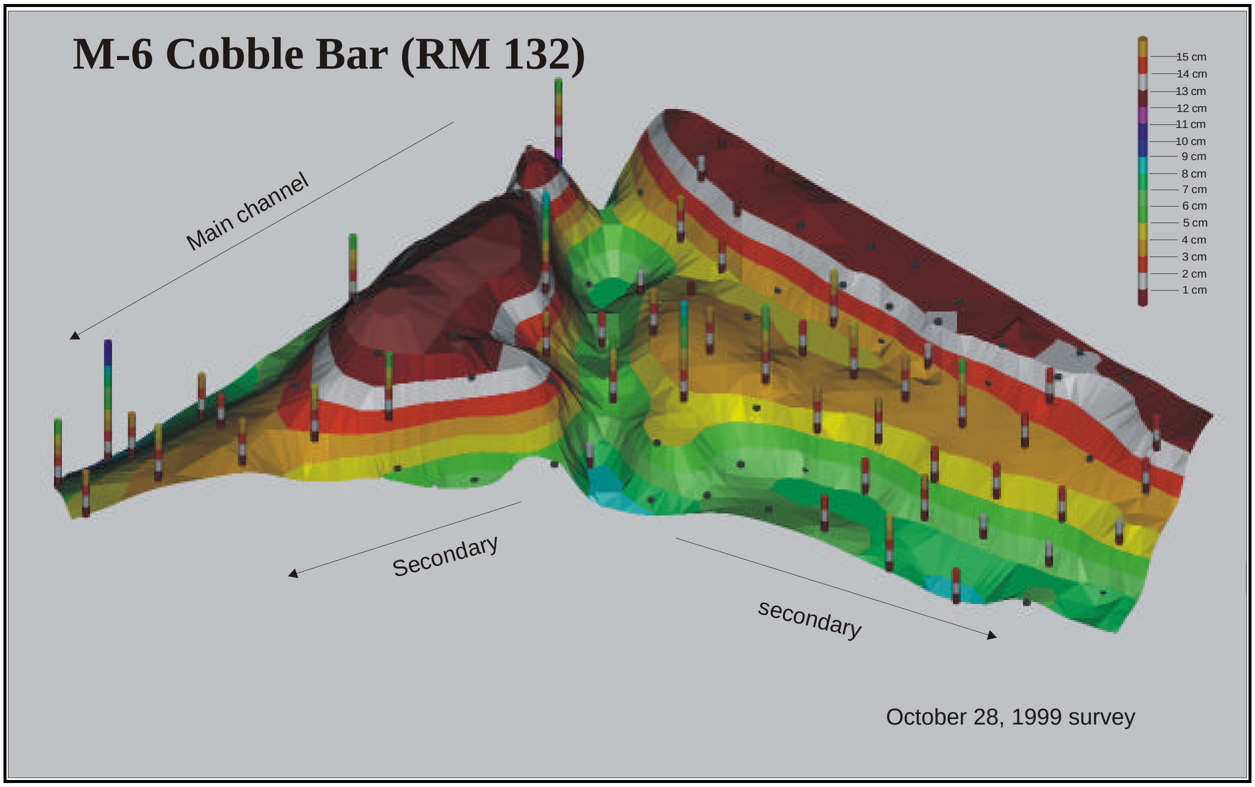

Figure 3.20. October 28, 1999 survey with embeddedness markers.

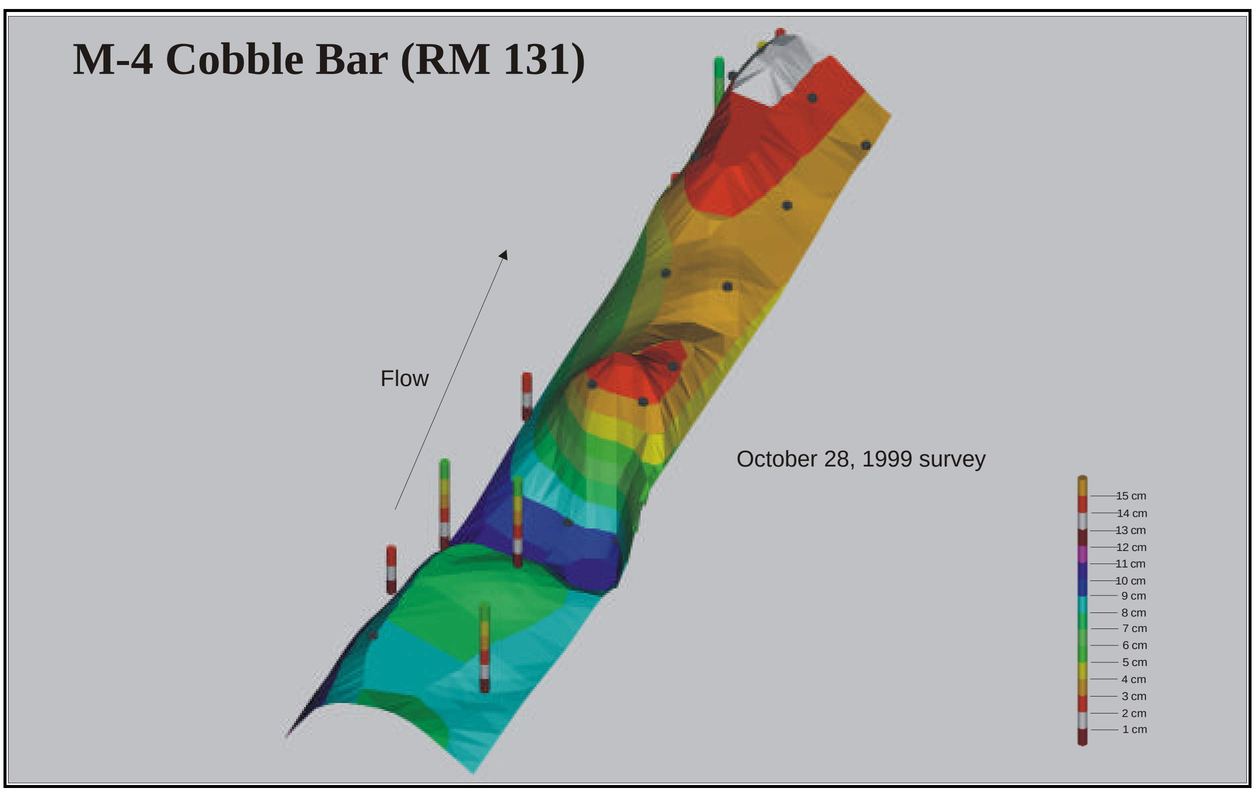

Figure 3.21. October 28, 1999 survey with embeddedness markers.

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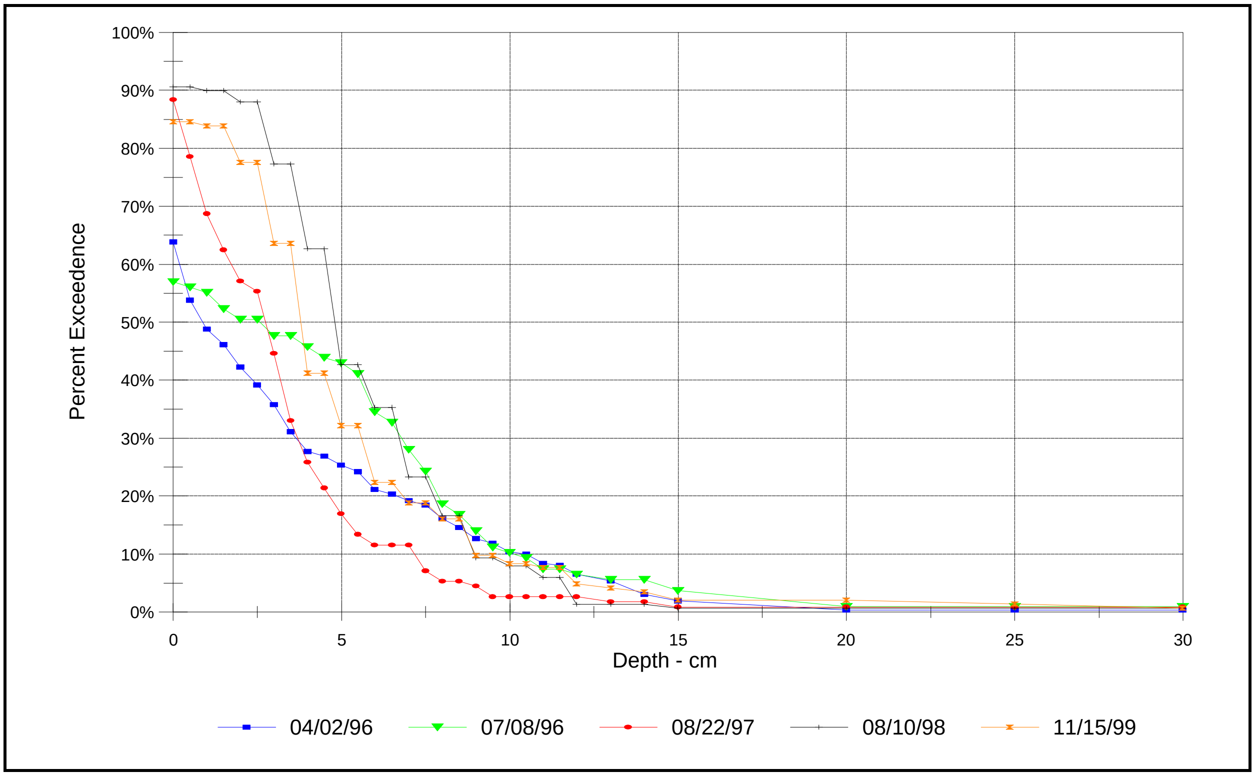

Figure 3.22. Frequency Distribution of Depth of Open Interstitial Space for Cobble Bar 173.7 expressed in cm.

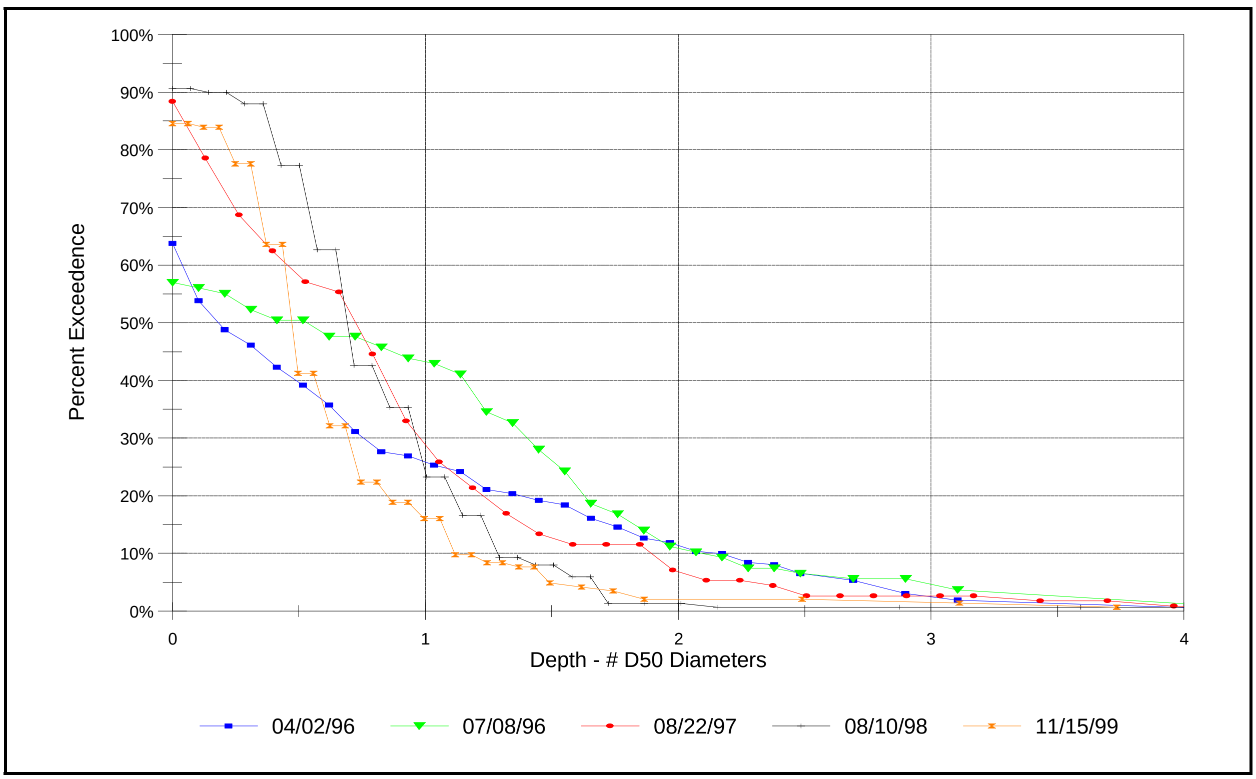

Figure 3.23. Frequency Distribution of Depth of Open Interstitial Space for Cobble Bar 173.7 expressed in d50 cobble size.

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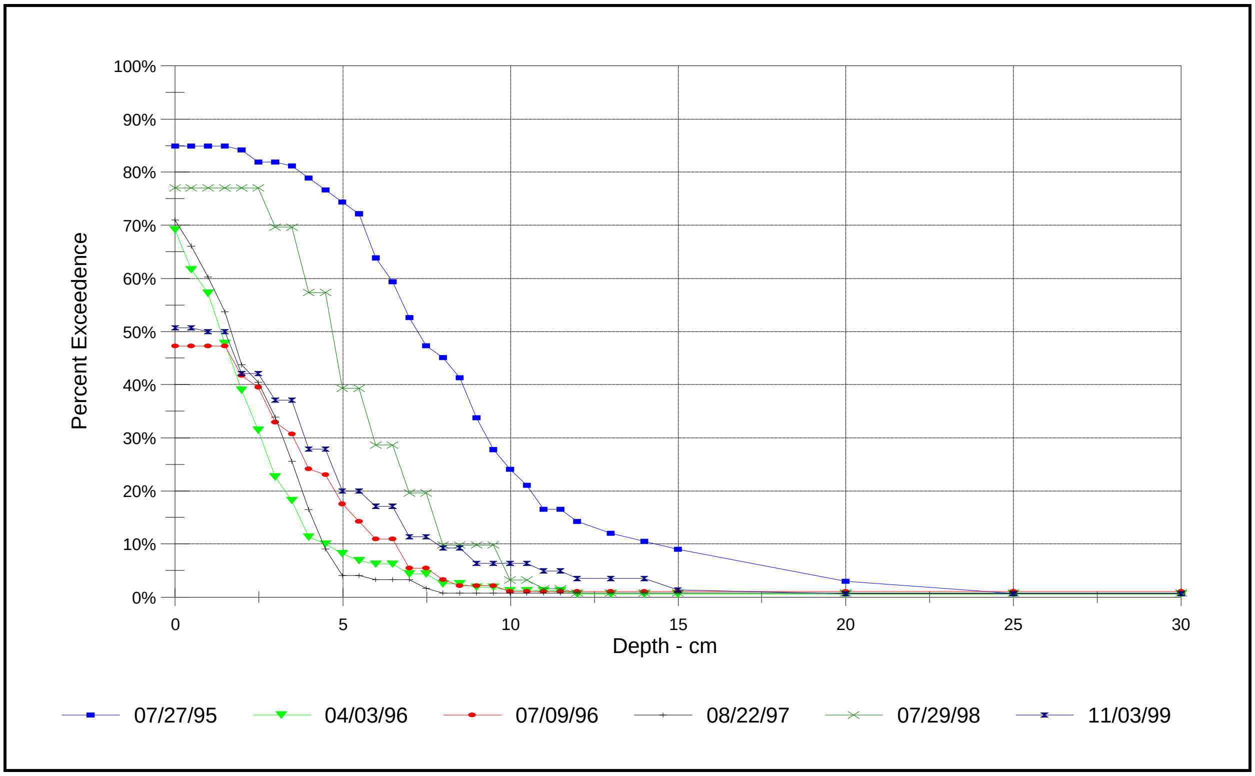

Figure 3.24. Frequency Distribution of Depth of Open Interstitial Space for Cobble Bar 168.4 expressed in cm.

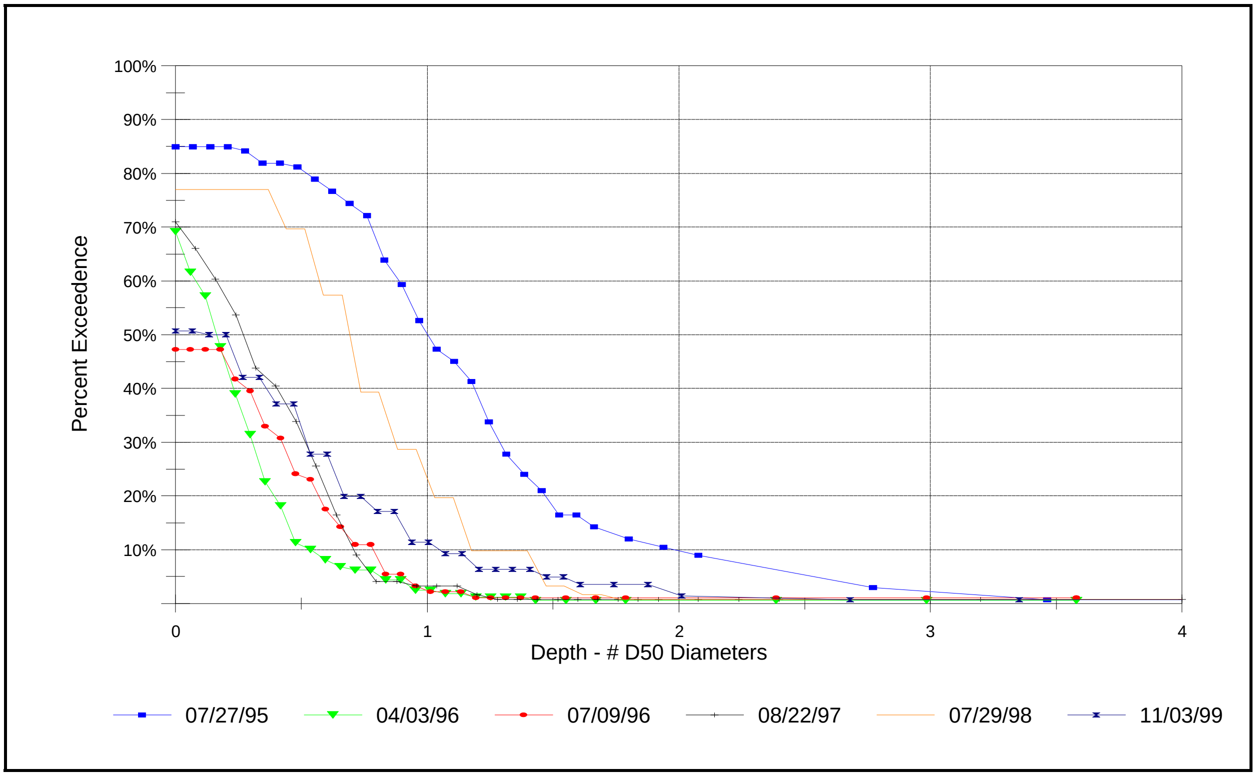

Figure 3.25. Frequency Distribution of Depth of Open Interstitial Space for Cobble Bar 168.4 expressed in d50 cobble size.

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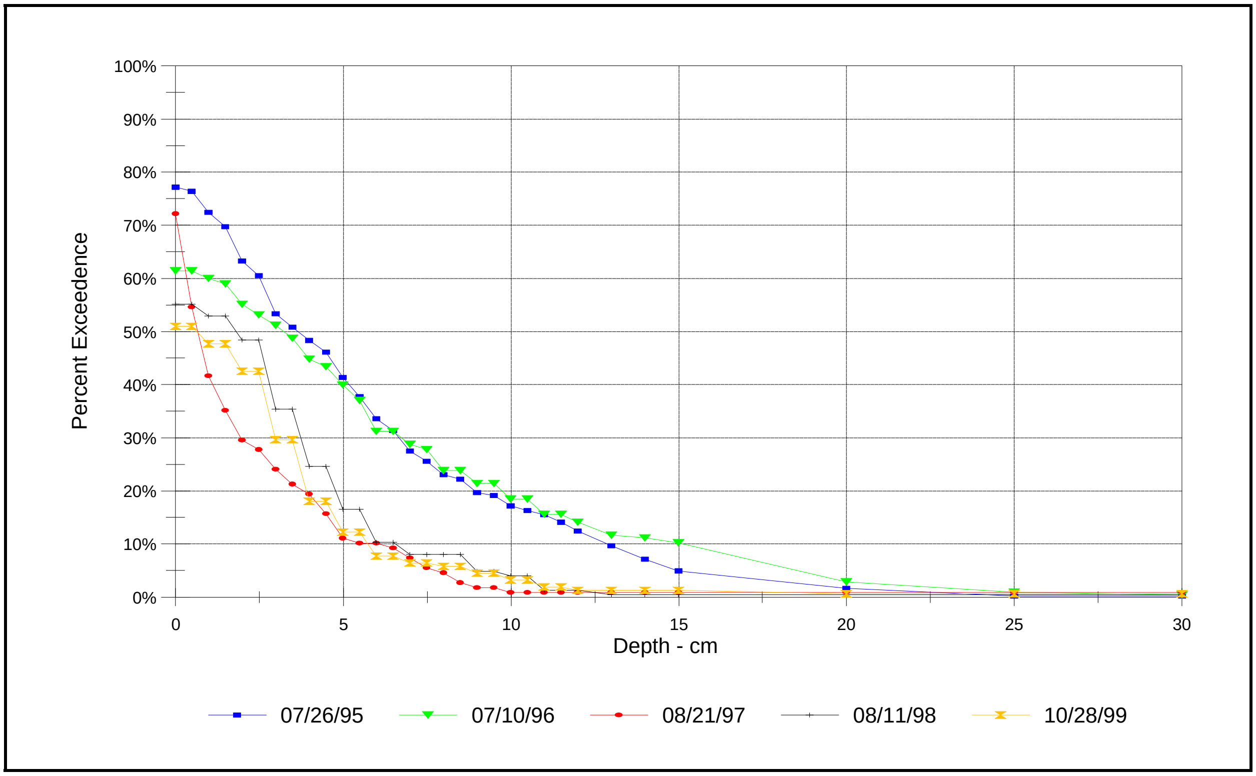

Figure 3.26. Frequency Distribution of Depth of Open Interstitial Space for Cobble Bar 132 (M-6) expressed in cm.

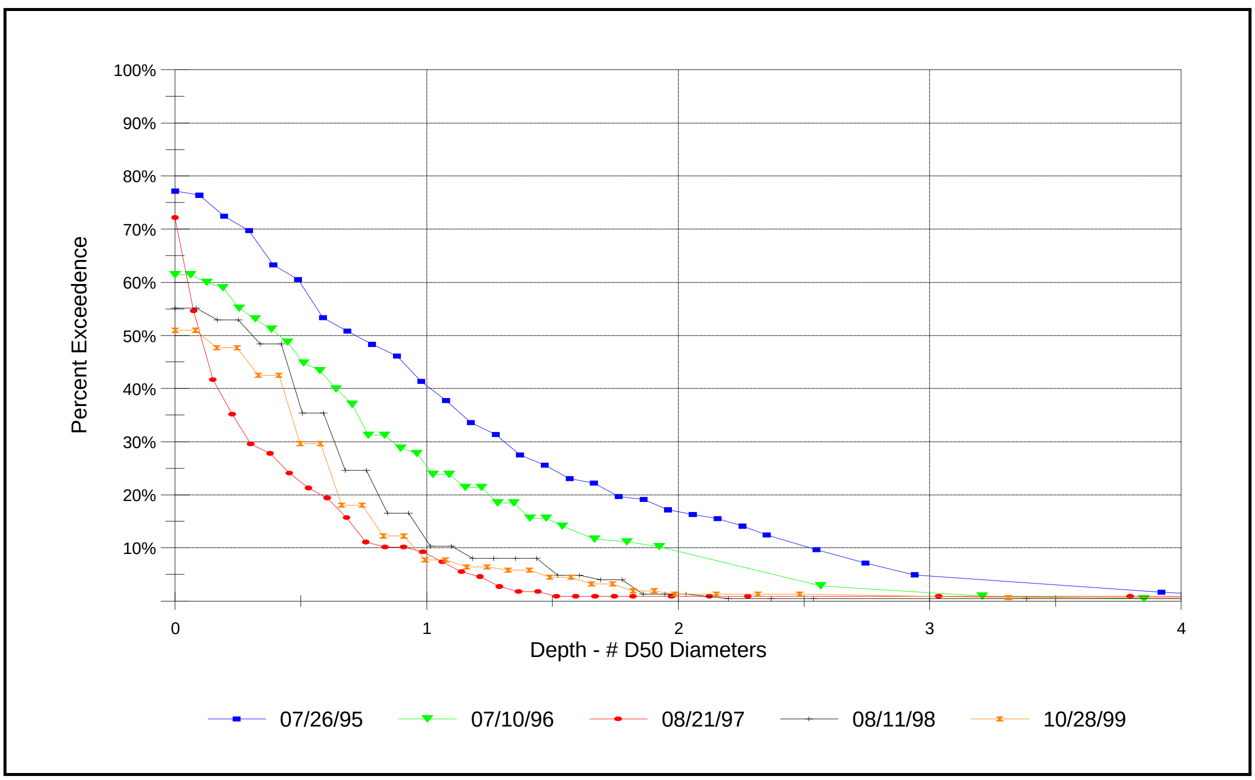

Figure 3.27. Frequency Distribution of Depth of Open Interstitial Space for Cobble Bar 132 (M-6) expressed in d50 cobble size.

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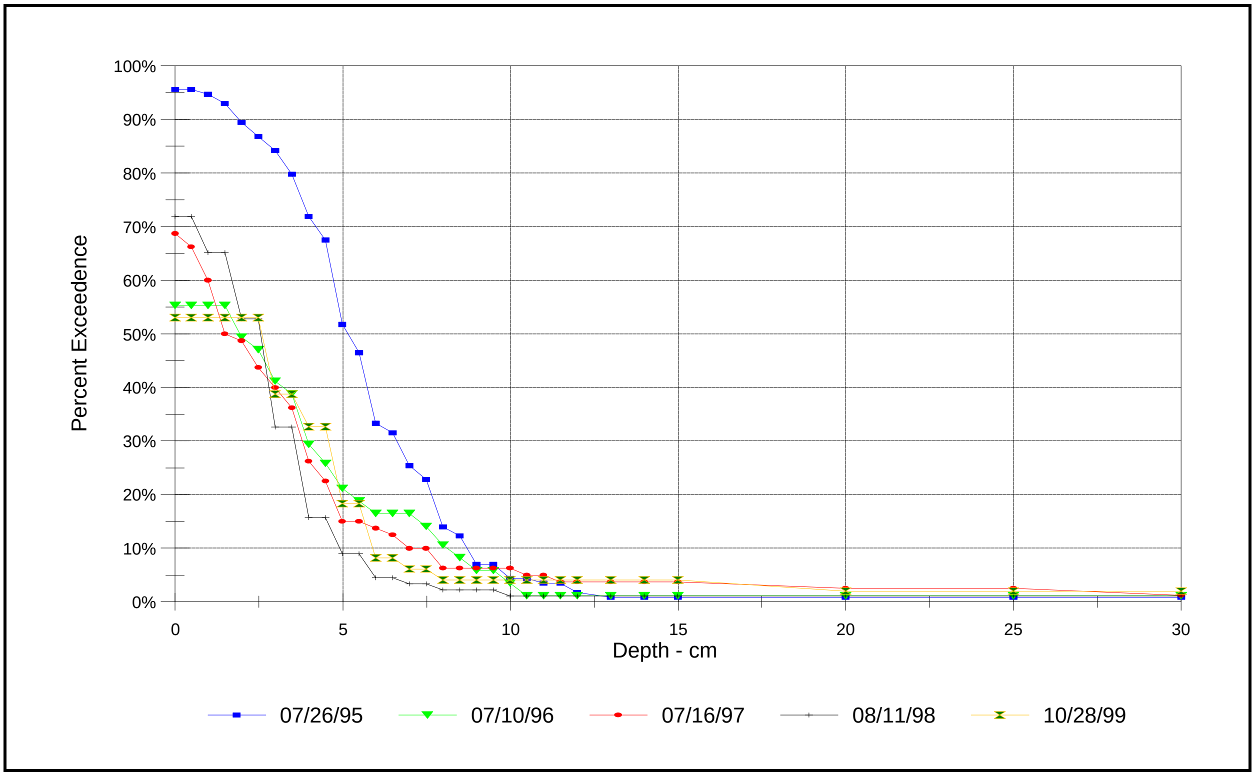

Figure 3.28. Frequency Distribution of Depth of Open Interstitial Space for Cobble Bar 131 (M-4) expressed in cm.

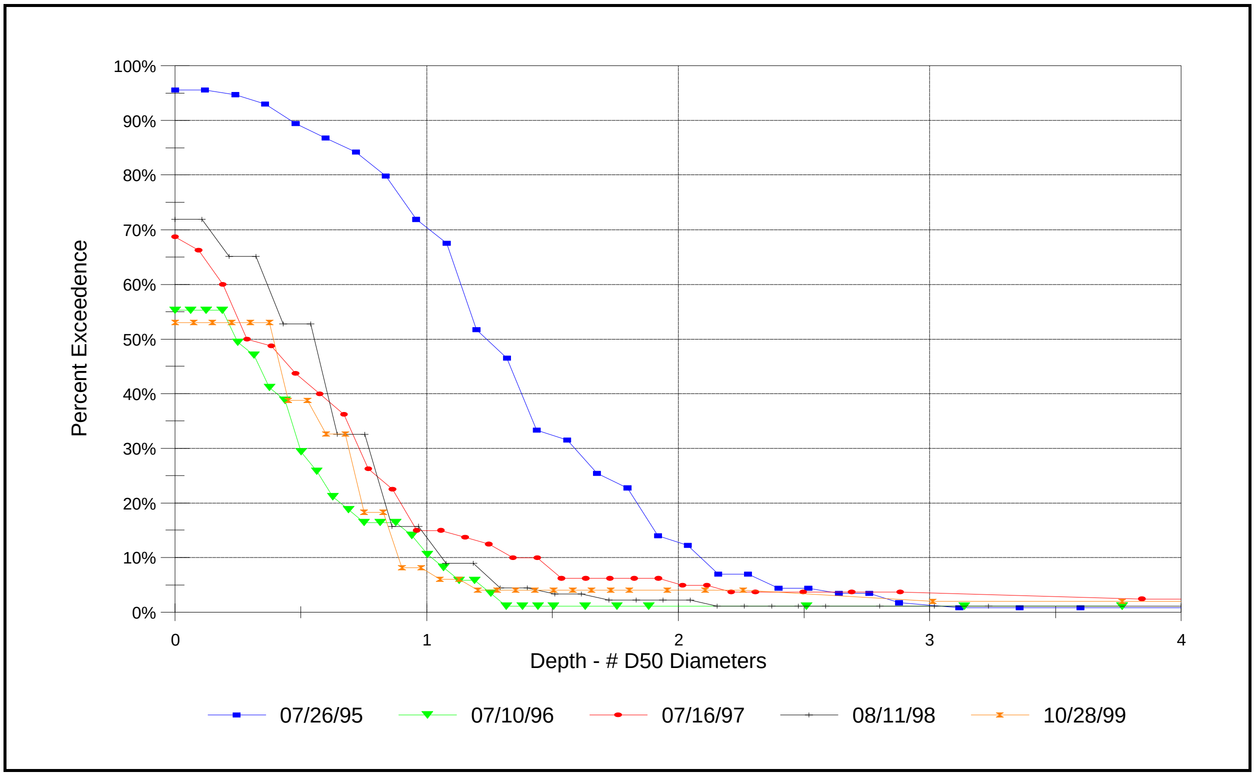

Figure 3.29. Frequency Distribution of Depth of Open Interstitial Space for Cobble Bar 131 (M-4) expressed in d50 cobble size.

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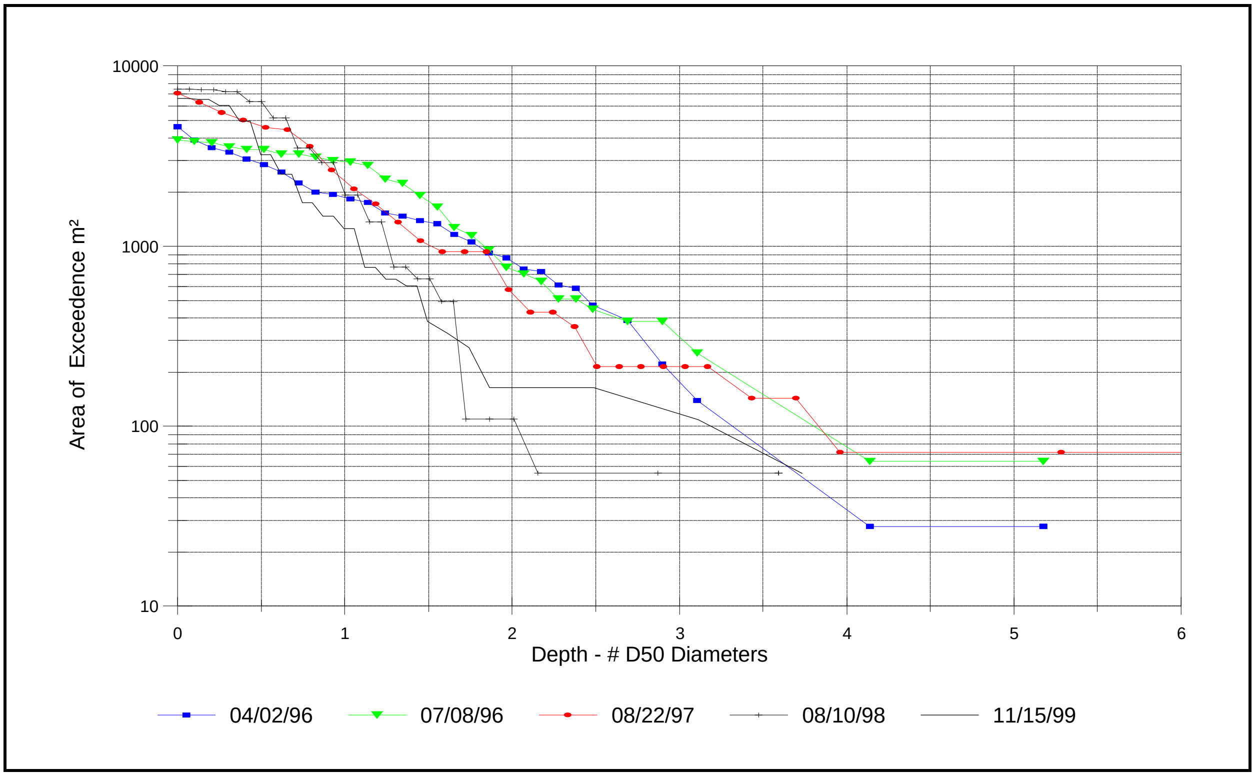

Figure 3.30. Area of Depth of Open Interstitial Space Exceedence for 173.7.

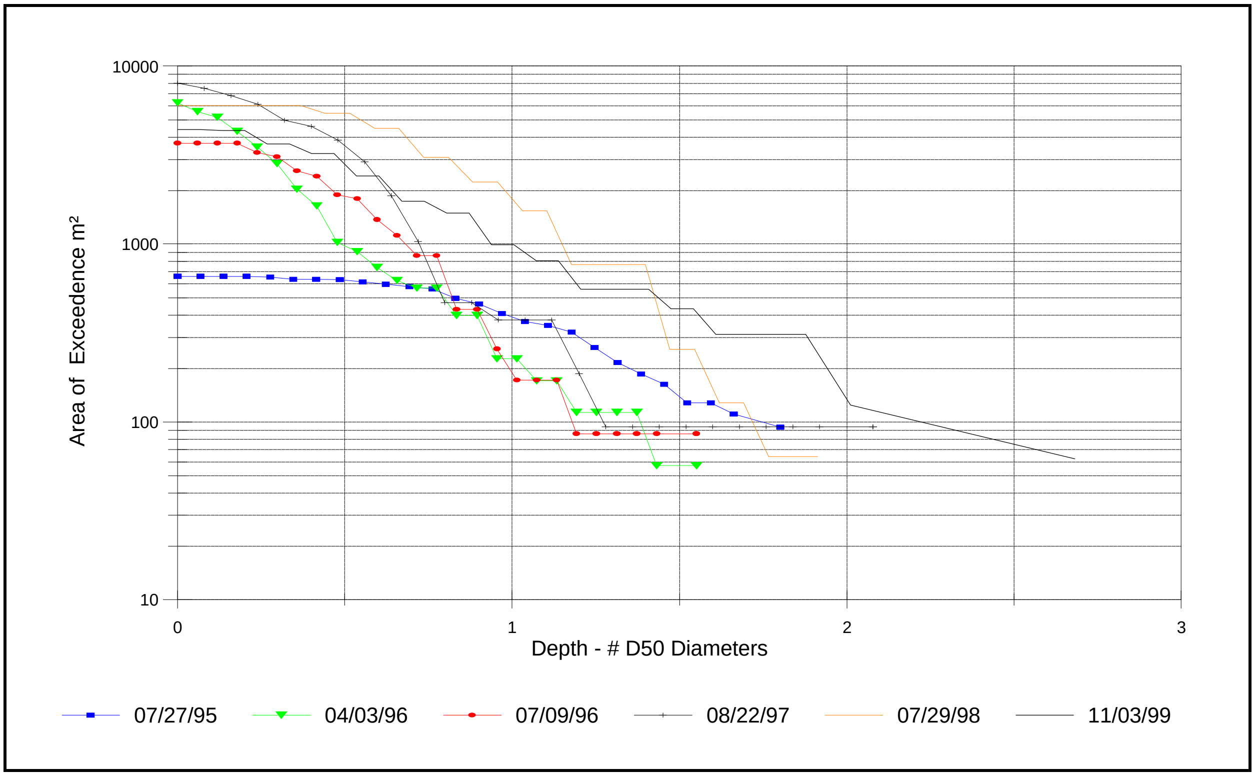

Figure 3.31. Area of Depth of Open Interstitial Space Exceedence for 168.4.

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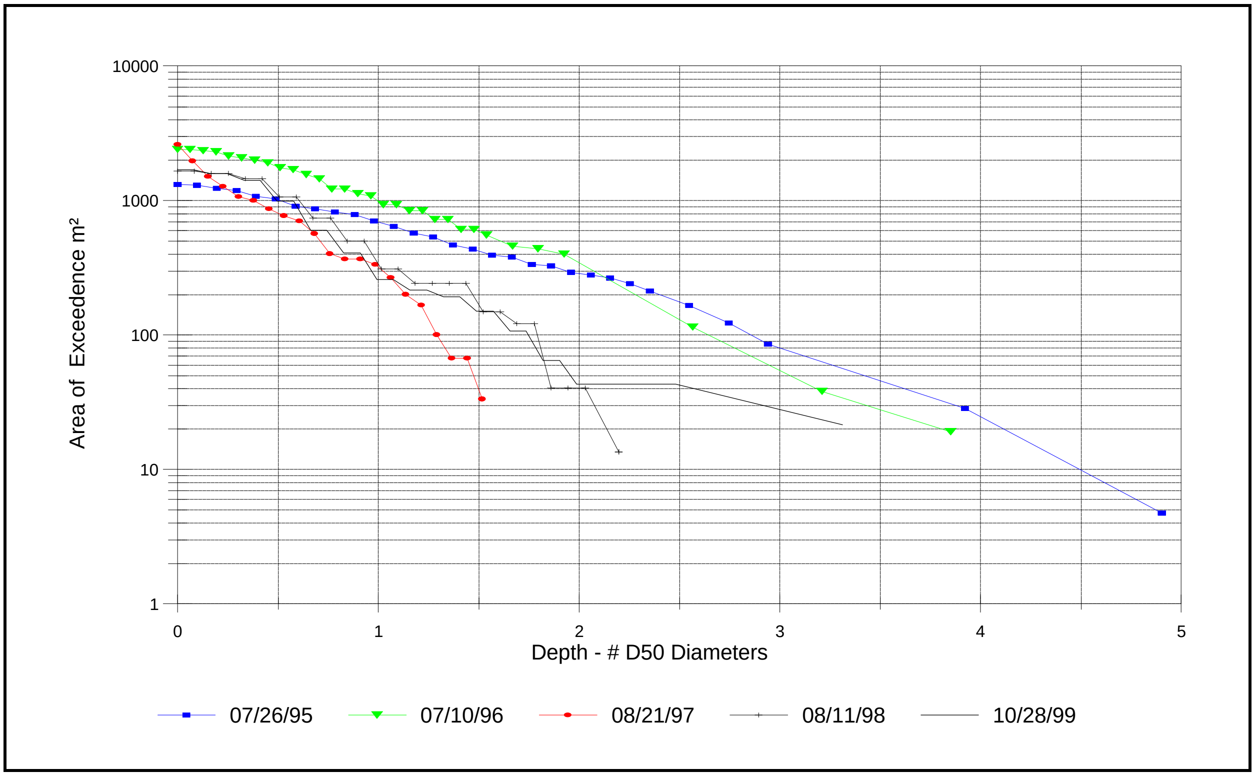

Figure 3.32. Area of Depth of Open Interstitial Space Exceedence for 132 (M-6).

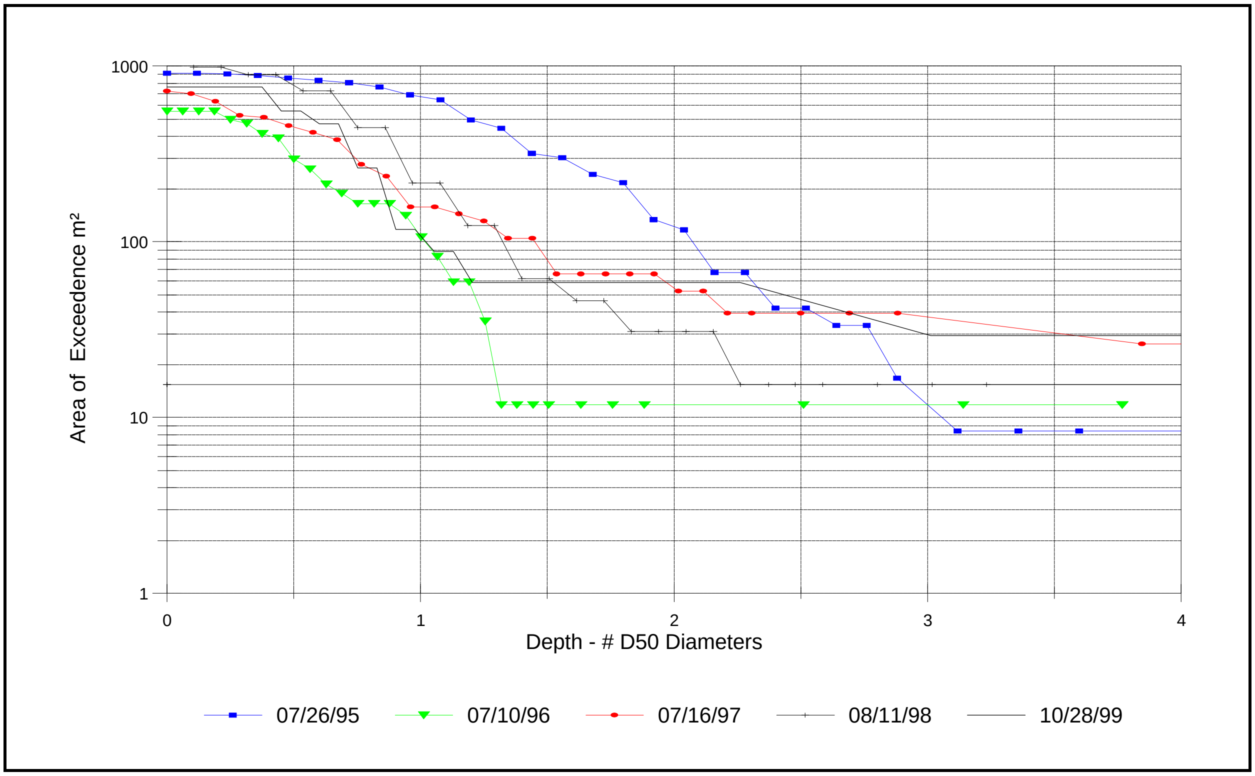

Figure 3.33. Area of Depth of Open Interstitial Space Exceedence for 131 (M-4).

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Suspended Sediment Analysis

Sediment Sampling

The results of the 1999 composite sediment sampling is shown in Figure 3.34. The plot shows the concentration at each station on the day of survey. Figure 3.35 shows the historical sediment concentration versus flow at Bluff as measured by the USGS from 1930 to 1980. The Bluff suspended sediment data gathered during the 1992 to 1999 research period is also shown. The collected data is within the historical concentration range.

Turbidity Monitoring

Turbidity equipment is installed at the USGS gage at Shiprock and at a site near the Montezuma Creek Bridge. The OBS-3 turbidity probe measures the optical properties of the water by emitting an infrared beam of light and measuring the backscatter. The sediment concentration and particle size distributions affect the back scatter. The probes are calibrated to read between 0-3000 NTU's (Nephelometric Turbidity Unit) at Montezuma Creek and 0- 4000 NTU's at Shiprock. The turbidity data collected in1998 and 1999 are shown plotted with USGS gage flow in Figures 3.36 and 3.37.

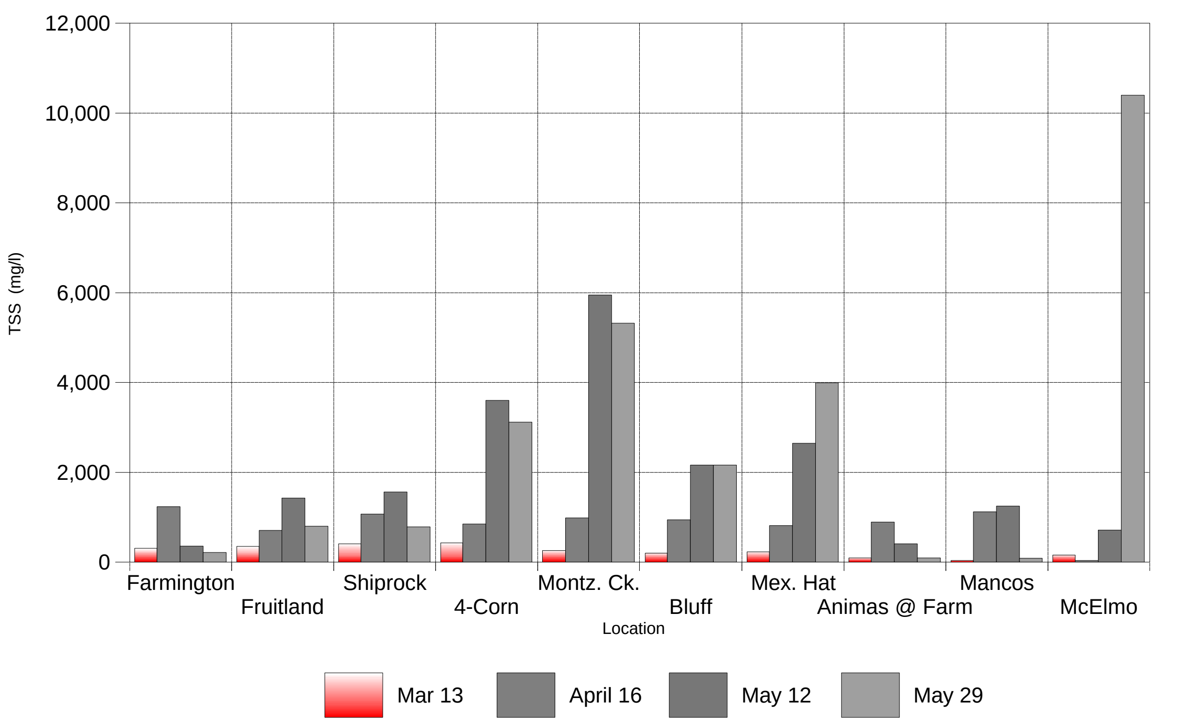

Figure 3.34. Results of 1999 Suspended Sediment Sampling

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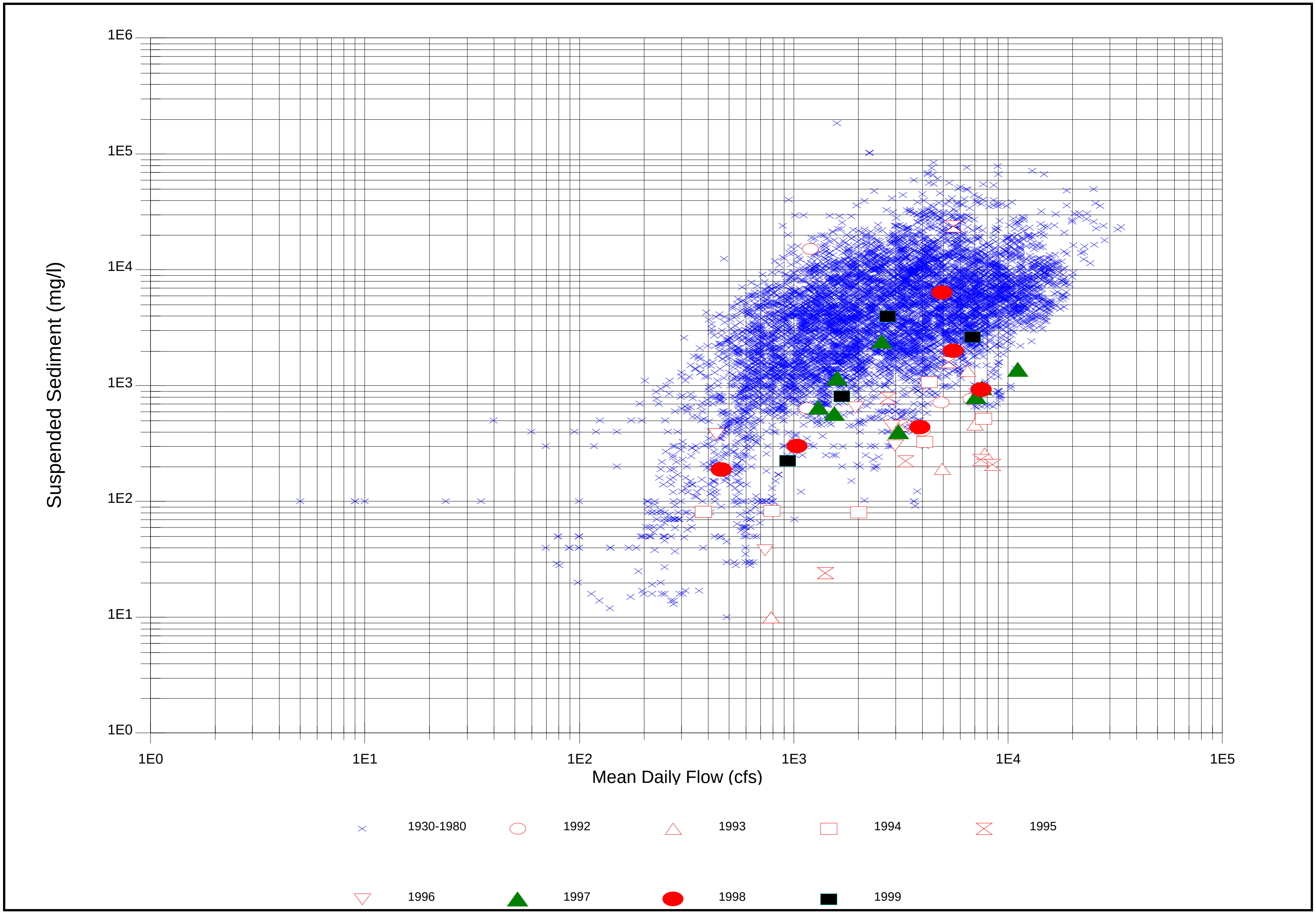

Figure 3.35. Historical Sediment Concentration at Bluff

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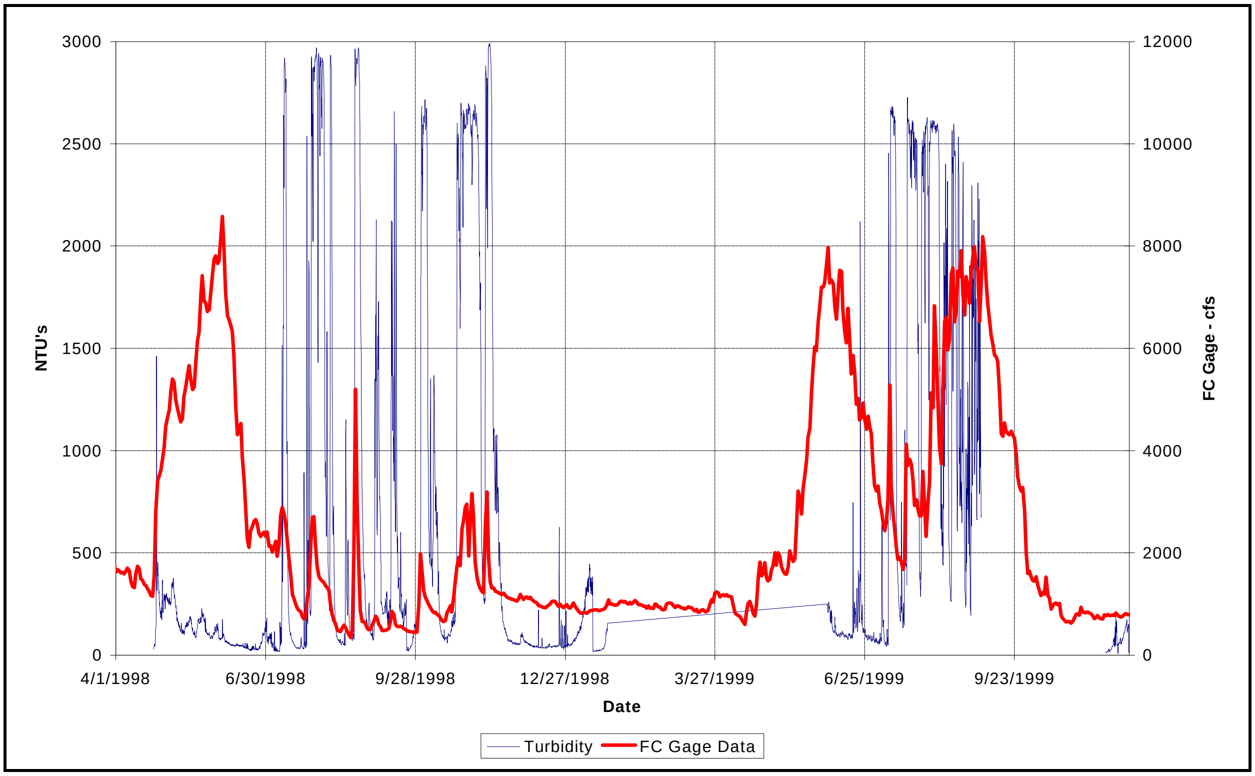

Figure 3.36. Montezuma Creek Turbidity Data and Four Corners Gage Flow

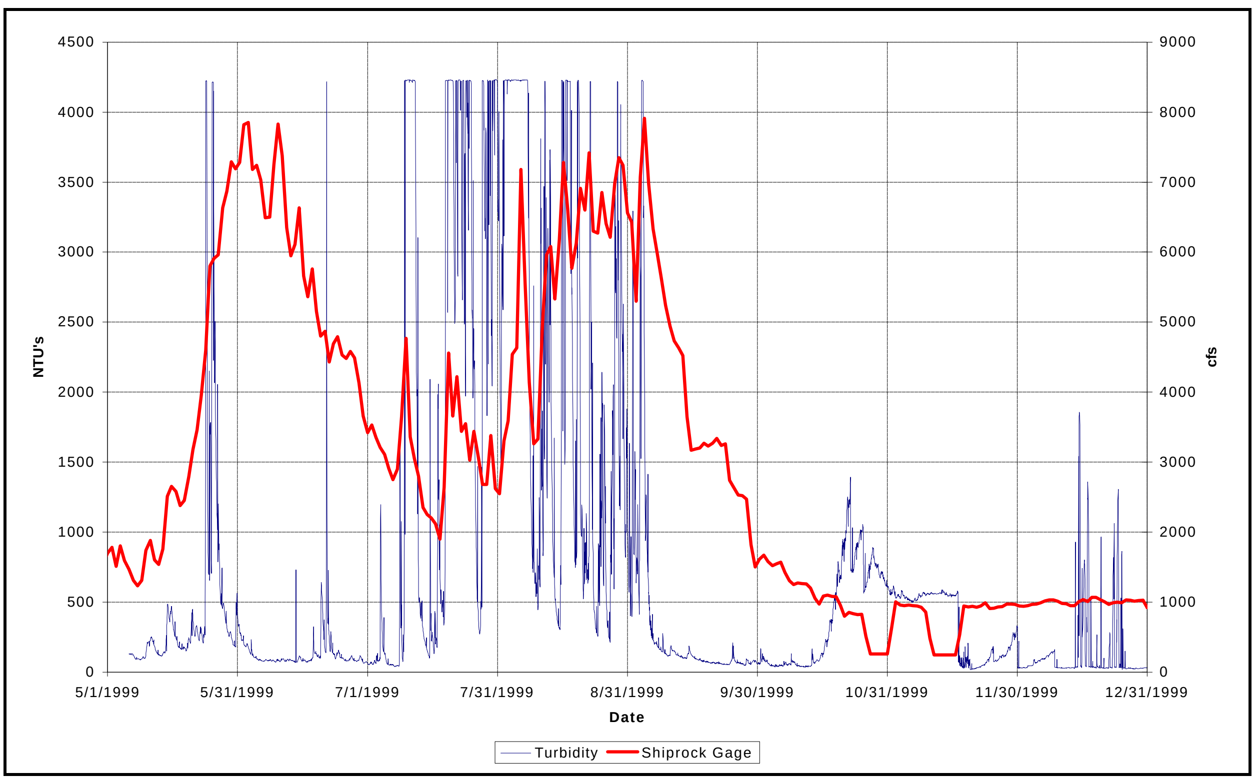

Figure 3.37. Shiprock Turbidity Data and Shiprock Gage Flow

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The turbidity equipment is used to continuously monitor sediment producing events. These events can result in large inflows of sediment that can reduce or eliminate spawning areas of endangered fish. By monitoring these events, reservoir operations the next year may be modified to provide flushing flows in an attempt flush the sediment through the system. These sediment producing events have been defined as storm event days. The definition of a storm event day is flow based. The following algorithm is used to determine Storm Event Days.

The storm event day calculation for Bluff is shown below. The subscripted numbers are day indicators. A 0 represents day 0 (today), -1 represents the previous day (yesterday), +1 represents the following day (tomorrow).

$Gain_0 = Bluff_0 - Animas_{-1} - Archuleta_{-2}$
    If [$Gain_0 - AverageGain_{(-2, -1, 0, 1, 2)}$ > 150 cfs]
        Then If [$Bluff_0 - AverageBluff_{(-2, -1, 0, 1, 2)}$ > 150 cfs]
            Then If [$Gain_0 - AverageGain_{(-2, -1, 0, 1, 2)}$ > 3000 cfs]
            Storm Event Day Flag = 2
            Storm Event Day Flag =1
        Storm Event Day Flag = 0
    Storm Event Day Flag = 0

Where,
- $Gain_0$ = The flow gain in cfs between Archuleta and Bluff.
- $Bluff_0$ = The flow at Bluff today
- $Animas_{-1}$ = The Animas contribution to the San Juan in cfs yesterday.
- $Archuleta_{-2}$ = The flow at Archuleta two days ago in cfs.
- $AverageGain_{(-2, -1, 0, 1, 2)}$ = The average gain over a 5-day period.
- $AverageBluff_{(-2, -1, 0, 1, 2)}$ = The average flow at Bluff over a 5-day period.

The above algorithm may be described as follows. The gain in flow between Bluff and Archuleta is determined after subtracting the Animas contribution. All other tributaries are ignored. The flow of the Animas is lagged one day and the flow at Archuleta is lagged two days. If this average gain is more than 150 cfs than the 5-day average and the average flow at Bluff is more than 150 cfs than the 5-day average, the day is flagged a storm event day. If the Gain is greater than 3,000 cfs, the day is given extra weight and counted as two days. A perturbating year is determined by summing the storm event days between July 25 and the end of February. If the number of storm event days is greater than 12 then the year is flagged as a perturbating year and additional flushing releases from Navajo may be necessary the following season.

The turbidity data were analyzed to see if it could be used to estimate storm event days and produce results similar to the flow based method described in the previous paragraph. The average daily turbidity data from Shiprock and Montezuma Creek were combined to produce a semi-complete data set. Even with combining the data there are 38-days of missing data between January 22 and February 28, 1999. On days with concurrent data, the station with the highest turbidity was used. The results of this analysis are shown in Table 3.6. The second column in the table shows the number of days that exceed 2600 NTU's. The third column shows the flow based sediment event

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days. For 1999, 2600 NTU's appears to be a good approximation of a storm event day turbidity based definition. This value was determined by iteratively adjusting the NTU level until the number of days exceeding a given NTU value reasonably corresponded to the flow based definition. The last column in the table shows the number of days where both methods produced sediment event days on the same date. Both methods would flag 1999 as perturbating years because of exceeding 12 sediment event days. However, the nature of the runoff in 1999, with the high summer flows probably mitigated a portion of the sediment flow days. The final test of perturbation is the condition of the backwaters, addressed in the backwater monitoring data.

Turbidity and Suspended Sediment Concentration

Turbidity monitors such as those installed at Shiprock and Montezuma Creek may be calibrated to read suspended solids directly. However, since turbidity sensors respond differently to varying size, composition, and shape of suspended particles, it is nearly impossible to do so accurately in an environment such as the San Juan River. The particles suspended in San Juan river water vary greatly in size and presumably shape and composition depending on the source of the suspended particles. In an attempt to develop a relationship between suspended sediment and turbidity, water samples were taken at the Shiprock and Montezuma Creek sites at the time of equipment service. The turbidity was then plotted against the concentration. These data are shown in Figure 3.38. Any pair of points with a NTU greater than 4000 were thrown out. The r^2 for the combined set of data as plotted is 0.59. The r^2 for the Shiprock data is .83 and for the Montezuma Creek data is 0.63. In general, the correlation is high enough to allow a reasonable prediction of sediment load based on turbidity. Since sediment sampling is not included in the long range monitoring plan, only turbidity data will be collected in the future.

Table 3.6. Flow based Sediment Event Days and Turbidity based Sediment Days.

Year	Days > 2600 NTU's	Flow Based Sediment Event Days	Concurrent Days
1999	17	15	8

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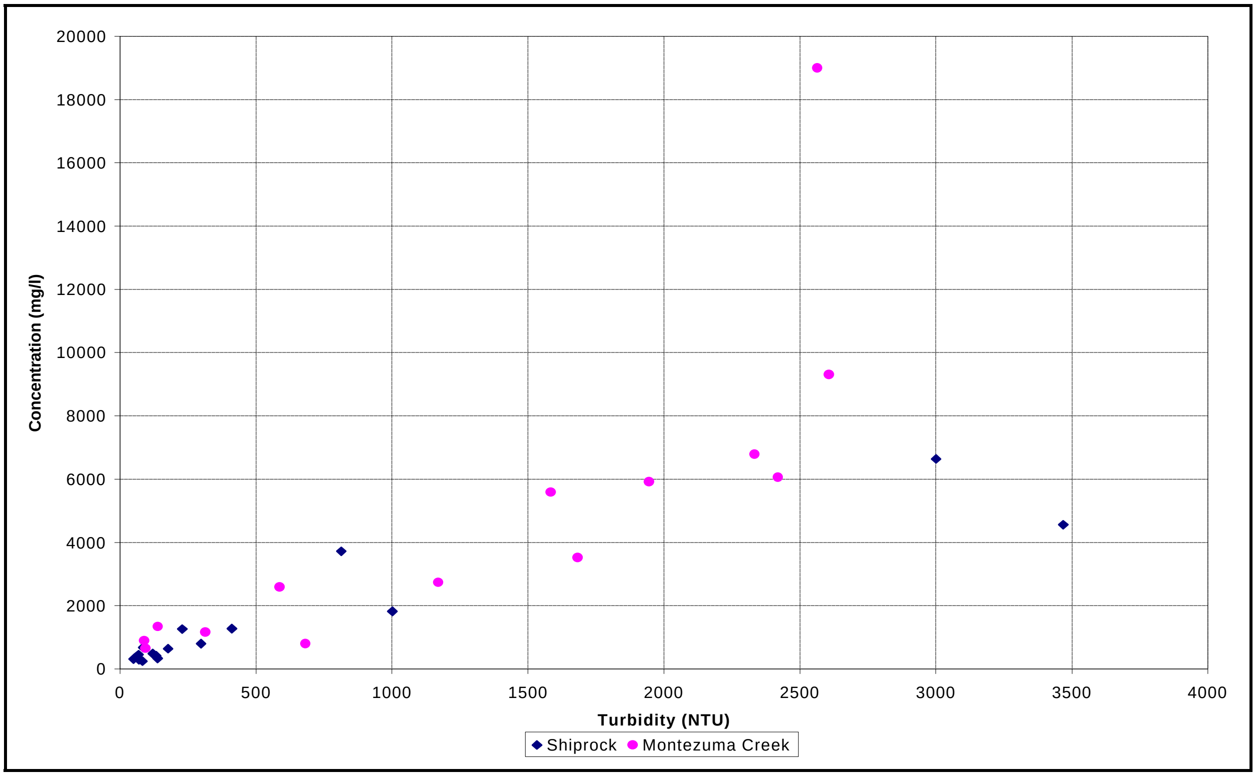

Figure 3.38. Montezuma Creek and Shiprock Turbidity versus Concentration.

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